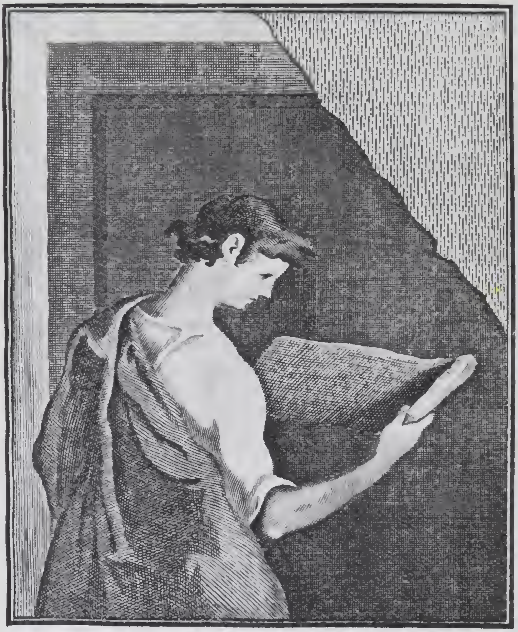
ART · ENAMELLING · UPON · METALS

CUNYNGHAME



ON THE THEORY AND PRACTICE OF ART-ENAMELLING UPON METALS

M'Lagan & Cumming, Edin.

Ada Hunter.

CRUCIFIXION.—One of a series of 18 enamels representing scenes from the life of Christ by J. Pénicaud II., date about 1530.

South Kensington Museum.

ON THE THEORY AND PRACTICE OF ART-ENAMELLING UPON METALS

BY HENRY CUNYNGHAME M.A

of the Home Department

WITH ILLUSTRATIONS

WESTMINSTER

ARCHIBALD CONSTABLE & CO

2 WHITEHALL GARDENS

1899

Butler & Tanner,
The Selwood Printing Works,
Frome, and London.

TO

WILLIAM HOLMAN HUNT

As a Tribute to his Genius and a Memento of

a friendship extending over

many years

PREFACE

THE wonderful development of modern machinery and of the factory system has produced, among other changes, the practice of making jewellery out of stamped metal—a practice which has deprived modern work of most of its artistic value. And, in consequence, the art-craftsman finds a difficulty in living. Moreover, the secrets that were once diffused through a corporate body of craftsmen are now in danger of becoming the exclusive property of manufacturers—so that the workman, even if he desires to do original artistic work, is in difficulty to know how to set about it.

Every one will admit that, for certain of the less skilled trades, work in a factory can be rendered more healthy and happy than in isolated places. But there are other and more artistic branches which are best pursued by the individual workman in his own house.

The Rue du Temple in Paris still abounds with

happy homes, where the master practises a lucrative art-craft in a part of the suite of rooms, and his wife and family live in the other. "La petite industrie" has not yet disappeared. And here are to be met enamellers, fan painters, delicate ivory carvers, who have not been drilled into mediocrity by the iron factory-system, but possess that independence of mind which is almost a necessity for a true art-craftsman. Unhappily the number of such men who once abounded in London is diminishing, and each year it is becoming more difficult to get anything done out of the common. In fact our national workshops are becoming filled with "hands," not men. To such, however, as are still able to attempt artistic work this book is addressed.

When I commenced the practice of enamelling I found it so difficult to get information, especially as to the making of enamels, for makers of coloured glass and enamels are generally very jealous of their secrets, that I determined to put such as I could obtain within reach of all our workmen. It is to them this book is addressed, for them it is intended, though I hope that some of our artistically-minded amateurs may be induced to benefit by it.

So far as the artistic side of enamelling is concerned I wish to acknowledge my indebtedness to

the lessons of Mr. Fisher, whose services as an instructor have been secured by the wise energy of the London County Council, and the Goldsmiths' Company. Also to Mr. Meyer, the ex-teacher of the Paris Municipal School of Enamelling, who has written an instructive work on the subject. It is to be regretted that the Paris Schools have been stopped. They have shown, however, what a stimulus municipal instruction can give to trade.

With regard to that part of the book which deals with the manner of making enamels, much that I am publishing is of the nature of trade secrets, but I have in no case revealed those that have been told me in confidence.

Every scrap of information that could be discovered in books has been utilized, from the work of the Monk Theophilus down to Thorpe's Dictionary of Chemistry, and all the publications I could hear of in German, French and Italian have been consulted. Every process has been repeatedly verified practically, and I have tried and suggested some new ones.

There is of course no finality in this matter. I have not the slightest doubt that these processes could be improved. I will, however, only say that I have executed many Limoges enamels with

colours made in the manner described. I still possess them, and I have not noticed any cracks upon them, even when put hot under a cold water tap, which is the most severe test an enamel can endure.

I do not suppose that most artists will make their own colours. They will probably be content to buy them. But I think that if a man devoted his life to working in enamel it would be worth his while to make his own materials.

HENRY CUNYNGHAME.

36, Eaton Place, S.W.

ON WEIGHTS AND MEASURES

I have generally used the metric system of weights. The English system is very complicated. It is as follows:—

AVOIRDUPOIS.

$27\frac{1}{3}$ grains	=	1 dram	=	1·77185	grammes.
16 drams	=	1 oz. ($437\frac{1}{2}$ grains)	=	28·34954	,,
16 oz. (7,000 grains)	=	1 lb.	=	453·59265	,,

TROY (for gold and silver only).

24 grains	=	1 pennyweight	=	1·55517	,,
20 pennyweights	=	1 oz. (480 grains)	=	31·10348	,,

APOTHECARIES (for drugs only).

20 grains	=	1 scruple	=	1·29598	,,
3 scruples	=	1 drachm	=	3·88794	,,
8 drachms	=	1 oz. (480 grains)	=	31·10348	,,

CONVERSELY.

1 gramme	=	15·43236 grains.
1 kilogramme	=	2·20462 lb.

LIQUID MEASURES for all Uses.

8 drachms	=	1 oz.	=	2·84123 centilitres.
20 oz.	=	1 pint	=	56·8246 ,,
2 pints	=	1 quart	=	113·6492 ,,
4 quarts	=	1 gallon	=	4·54596 litres.

In French measure a litre of water weighs a kilo-

gramme (almost exactly), and a cubic centimetre of water weighs exactly a gramme.

The relationship between weights and measures of capacity in England is that one gallon weighs 10 lb. avoirdupois, and hence an ounce of fluid measure of water weighs an ounce avoirdupois weight.

MEASURES OF LENGTH.

1 inch	=	2·539 centimetres.
1 centimetre	=	·39370 inch.

The purity of gold and silver is estimated in twenty-fourth parts. Thus 18-carat gold means gold in which 18 out of 24 parts are "fine" or pure gold; the rest is alloy.

A diamond carat weighs in England 3·166 grains.

The value of fine gold is from 86*s*. to 90*s*. per oz. (troy = 480 grains), according as it is granulated or in sheet or wire. That got from refiners is rarely quite pure; it usually contains a thousandth part of silver. But it can be got absolutely pure from dentists' material dealers. Fine silver is worth about 3*s*. an ounce (troy).

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Chapter I

INTRODUCTION

THE process of enamelling consists in coating the surface of earthenware, porcelain, glass, metal, or any other substance that will bear to be raised to a red heat with a layer of melted glass. The origin of the name is doubtful. It probably is connected with the word "smelt," and the German "smeltzen," from which also the word "smalt" is derived. In old French it was spelt "esmail." A mere uniform glaze of glass, such as is used to cover pottery and porcelain, is sometimes termed enamel, but more strictly the word is only used when the glaze is laid on so as to form a design. The use of the word should also in strictness be confined to cases in which coloured glass is employed, laid on in masses like washes of colour, and not to work painted with a brush.

Thus when china or metal is covered with solid coats of glaze it is said to be enamelled, but stippled ornaments or landscapes upon Dresden china, or Battersea ware, are not enamels properly so called.

In practice the word is loosely employed, and it is

usual to call all applications of melted glass upon metal by the name enamel, so that the term is employed for saucepans and other kinds of household ware made by coating iron with vitreous material.

The so-called enamels used on bicycles are not true enamels, but only preparations of pitch or other resinous substances, which are hardened by baking them for two or three hours in ovens at a temperature rather higher than that of boiling water. Used in this way, common Japan black produces a hard and beautiful surface; but it is not a true enamel. Enterprising tradesmen sometimes mix two or three pennyworth of paint with a hard varnish, strain it, and sell it in tins as "enamel." Ladies' faces are also "enamelled" by the application of certain cosmetics. But these are all improper uses of the word.

It has been found that several metals, among which are gold, silver, iron, copper and fine bronze, that is to say, copper with a small admixture of tin, are capable of being covered with glass, fused on to them by means of heat. But to other metals, such as nickel, or zinc, or brass—which is a mixture of copper and zinc—the glass will not adhere. The usual method of applying the glass is to reduce it to fine powder, to spread it over the metal in a thin layer, and then to put the metal into a furnace raised to a red heat, until the glass melts.

Glass is coloured by melting it with the oxides of various metals. Oxide of tin makes it opaque white, iron gives a sea green and a yellow, cobalt a royal blue, copper a turquoise blue. Manganese colours glass violet, silver and antimony yellow, and gold

crimson. These were the metals used by the old enamellers. In addition we now have chromium, giving another shade of green; uranium, a fine yellow; and iridium, giving steel grey and black. The nature of the glass used in enamelling, and the mode of making it, colouring it, and applying it to metal will be fully explained and treated practically in the subsequent portion of this book.

In ancient times it is certain that the use of coloured glass as a decoration for pottery and porcelain was known. The Egyptians used a fine royal blue glaze on the small images of mummies, which they placed in tombs to be the servants of the dead in the next world. Its use upon metal is more doubtful. Many Egyptian jewels have been found ornamented with what appears at first sight to be enamel; but further examination shows that in most instances small pieces of marble or glass have been cut out and fastened into recesses in the metal with cement. Specimens of true enamel upon metal executed by the ancient Greeks are to be seen in the British Museum. The Celts and Goths seem also to have known the art of enamelling. There is at Oxford, in the Ashmolean Museum, a ring of Alfred the Great with a Byzantine enamel in a Saxon setting. The rarity and value of these specimens render it difficult to submit them to chemical analysis.

I do not propose to enter into an archæological discussion upon enamels. Those who are interested in such inquiries may consult a very instructive little treatise in French by E. Molinier, the accomplished custodian of the Louvre enamels—Librairie Hachette, Paris, 1891.

I propose to consider the question from a practical point of view, and therefore shall confine my observations upon the history of enamelling to such an outline as is necessary to explain its character and mode of execution.

Architecture has always occupied the leading position among the arts, and this is natural, considering that it concerns the palaces, churches, and houses in which men live and worship. Sculpture, painting, goldsmiths' work, tapestry, wood-carving, pottery, stained-window-making were all in their origin auxiliary to the decoration of the splendid temples and palaces and cathedrals which were the objects of so much labour in bygone ages. It is therefore natural to expect that the various changes of style of architecture which have taken place should have been accompanied by corresponding changes in the arts which were employed to adorn it.

Classic architecture, like classic literature, was chiefly designed to satisfy the desire for the beautiful, and accordingly the leading characteristics of classic sculpture and painting were beauty and harmony of proportion.

In their anxiety to shake off the corrupt morality of the old world, the leaders of the early Christian Church endeavoured to sever all connection with art. This prompted them to destroy the voluptuous statues and paintings of paganism, and caused a total discontinuance of representations of the nude figure. The same feeling produced societies of Anchorites, by whom all human enjoyment, and even family life, were looked upon as sinful.

But the mass of mankind could not dispense with art, and their desires could only be satisfied by new developments of the old forms. Accordingly Christian art is a continuation of classical art, into which a nobler and higher feeling has been infused, and which, not content with what is merely beautiful and noble, aims at the spiritual, the mysterious and the sublime.

In its later forms Greek art reflected the feelings and the degeneracy of a dying world. Those who desire to experience it will find it in literature in the Milesian tales, or the story of Cupid and Psyche. In sculpture it is reflected in the small tinted statuettes to be found in most museums. The severity of earlier times has given place to a cloying sweetness, which, though charming, is instinctively felt to be wanting in manly vigour. Such work is more appropriate to the boudoir of Aspasia, than to the home of the mother of the Gracchi.

With Christianity the Stoic spirit revived, and art took a severer form. The early Christian Church had before her eyes the spectacle of a world which had perished through the immoderate use of art. Weary of the babbling of the schools of rhetoric, men turned to the silence of the cloister. The desert was a necessary protest against the gormandism of later Roman times; celibacy was a reaction against universal sexual profligacy.

And the Church, therefore, seems to have resolved to curb the arts, and for the future to retain them in the strictest leading strings.

The languishing embraces of graceful Greek gods were exchanged for the severe and even repellent

types of Byzantine Mosaics. But this very restraint, salutary as it was while the morals of Europe were being reformed, was not without disadvantages; for where literature or art is in complete subjection to a system of morals, religion or politics, it is certain to be cramped down and kept in bondage by artificial rules which destroy its vitality. Therefore, though the fire of Christianity purged classical art of most of its dross, it destroyed a good deal that was valuable in the process.

Thus the extraordinary capacity which the Egyptians displayed for sculpture and painting was diverted by the influence of the priests into a monotonous circle of endless repetition; and Christian art in the East was subjected to a written code by which the exact position and dress of each figure, the colour, and attitudes were minutely prescribed, and no departure permitted from rigid rules.

It is no reproach to religion that it should thus have restricted art. A man whose thoughts are wholly occupied with spiritual things naturally values pictures or images purely for the spiritual ideas presented by them, and may even be disturbed and repelled by the introduction of mundane beauty.

The rejection of ornate ritual and church decoration is partly due to this feeling. But it is also true that an art which is intended to appeal not to Anchorites or Puritans, but to ordinary men, must satisfy not only the moral, but also the æsthetic sentiments. Therefore the perfection of national sacred art is seen when the highest beauty has been reached without the sacrifice of pure and noble religious feeling. The work of art must, so to

speak, have a noble soul enshrined in a beautiful body.

The Eastern Empire, whose centre was at Byzantium, gave rise to a style known as the Byzantine, North Italy was represented by the Lombard style, while the Western world created Gothic. Byzantine art is best seen in the two principal monuments of it that still remain: the Mosque of St. Sophia at Constantinople, and the Ducal Chapel at Venice. St. Sophia must once have been filled with the most splendid enamels, but these have all been destroyed, either by the cupidity of the pirate crusaders, or by the fanaticism of the followers of Dost Mahommed. Several most interesting specimens exist, however, at St. Mark's in Venice, and at Limburg.

Byzantine enamel was always of the kind known as cloisonné or "partitioned." It was made by marking the outlines of a drawing upon a plate of gold, and then soldering on the gold plate, over those outlines, small strips of gold, about $\frac{1}{100}$th inch thick and $\frac{1}{50}$th inch high. These, like small hedges, mapped out the surface into areas, which were then filled with powdered glass, melted in by means of heat. The designs were very rigid and conventional, and at first sight, to our eyes, appear even ridiculous; but this is because Byzantine art has always for centuries been subject to a written code of rules, specifically directing how various religious subjects should be treated. No scope was therefore afforded for originality, but he who will examine Byzantine enamels, from the point of view of those who ordered and executed them, will find much to admire. The

gestures of the figures are symbolic, and even in a sense mystic. They are religious hieroglyphics rather than pictures, but as an assistance to devotion to those who were working out the conceptions which the Eastern Church brought as her contribution to Christian theology, they were probably more effectual than creations of later date. Considered simply from the standpoint of religious art they are superior to the groups of fat, half-naked, howling women which Rubens introduced into his pictures of the Crucifixion.

Very few specimens exist of early enamels executed in the Western or Roman Church prior to the 11th century, but the little that remains shows that it was cloisonné work. The Paliotto in the cathedral at Milan is the most important specimen. The Byzantine Church has, since the 10th century, been barren of artistic idea. No new forms of architecture have been invented, painting has remained stationary; but the close of the dark ages witnessed the infusion of a new spirit into the Church of the West. Lombard architecture received a great impulse after the year 1000, in which it was believed that the world would come to an end, had passed. In France and Germany Gothic architecture awoke to life with the invention of the pointed arch in the 12th century, and the satellite arts of painting and sculpture followed the lead, so that the 12th, 13th, 14th, and 15th centuries present a regular and continuous progress. This age witnessed the building of the great cathedrals; but in spite of the apparent increase of episcopal power, a revolt had commenced against excessive clericalism, and archi-

tecture and the subordinate arts experienced the effects of it.

Human emotions and sentiments and passions began to be introduced in connection with sacred subjects, and formal traditions were abandoned in favour of a study of nature. The way was being prepared for the Renaissance and Reformation. Under this influence the arts bloomed into the fairest forms. The capitals of pillars were festooned with field flowers; lizards and animals nestled in the foliage; kings, hunters and handicraftsmen were represented in stone.

Painting, in the hands of the early Italian masters, cast off old rigid Byzantine traditions, and the faces of Madonnas and of the infant Jesus began to beam with human sympathy, while at the same time the limbs approached more nearly antique models, and the drapery became more flowing and natural. At this period art was imbued with the feeling for humanity, without having lost the inspiration of the divine. This union of the sublime and beautiful was the secret of its success.

The characteristic of Gothic times was carving. Almost all ornamental things were produced with the knife and chisel. Wood and ivory have never been so splendidly treated. Accordingly the mode of making enamels underwent a corresponding change. Instead of being fused into cloisons, the glass was melted into cavities cut out of solid metal. This is called champlevé. It is not clear from whence this art originated, but it is certain that Limoges speedily became its headquarters. There is reason to think that it was imported from Venice, from which place

also came the lead-glass necessary to make it. The Venetians had in their turn probably learned the art of making the glass from Constantinople.

The metal employed as a foundation was bronze, that is to say, copper mixed with about ten per cent. of tin, or else brass (copper and zinc). The hollows were cut out to the depth of about one-twentieth of an inch and left rough at the bottom, so as to give a better hold to the enamel, which was opaque, and made by staining opaque-white enamel with the oxides of various metals, so as to produce two or three shades of blue and green, yellow and black.

Opaque-white was made by melting glass with "putty powder," or poudre d'étain. This is obtained by skimming off the oxide that forms upon melted pewter (a mixture of tin and lead). Putty powder is also used for polishing glass. The colours used for staining the opaque-white glass were "saffre," an ore containing cobalt and sulphur, which gave blue. Turquoise was obtained from the black scales that form upon copper when it is raised to a red heat, green from the scales that form on red-hot iron. Yellow was got from antimony, and red from iron, and also by a special treatment from copper.

The faces in Limoges champlevé were generally left unenamelled, but chased up and filled in with black, like church brasses. Sometimes the heads were modelled in relief, and fastened on with rivets. Each colour was usually put in a separate compartment, but sometimes two colours will be found in juxtaposition in one compartment. The face of the enamel was ground and polished, and the metal work

Part of a Crucifix in Champlevé Enamel, in the possession of Mr. Morland.

was frequently gilded by the mercury process, which only requires a low heat. The mercurial process of gilding is one of great antiquity, being mentioned by the monk Theophilus, who wrote in the 11th century. It was employed till it was replaced in the present century by electrogilding. It is more durable and beautiful than gilding by electricity, but is tedious and dangerous to the health of the workman.

It is impossible to give very high praise to the later work in champlevé of Limoges, which exhibits all the faults of the Byzantine work, without its merits. It is usually slovenly and mechanical, although sometimes pieces are found of exceptional excellence. It is often miscalled "Byzantine." But the Byzantines never made champlevé, and in Gothic times cloisonné was rarely practised in the West, except for jewels and personal ornaments.

Some of the best champlevé work was done in the form of small plates or buttons, which were fastened on to shrines and crucifixes in company with jewels set in gold or silver.

The colours used for champlevé were mostly opaque. The monk Theophilus tells us that in times prior to his day the glass workers took all the small antique vases and pieces of mosaic they could find or dig up, and remelted them to make enamel. Even in his time the art was so little advanced that he treats the obtaining of colour quite as a chance operation, recommending the artist to make the colours haphazard, and pick out those which he prefers.

Gold was also used for champlevé work, but usually (except for jewellery) with transparent enamels. Unfortunately these works have been mostly melted

up, but what remains of them must make us bitterly regret what has been lost. The later style of this is called "basse-taille," and consists in carving out a subject in a thick plate of gold in low relief. The mode of execution is like that used by the Egyptian sculptors. A firm, sharp outline is cut, and the figure is moulded within it. The object of the Egyptians in this sort of sculpture was that the sunlight, by casting a shadow, might produce a firm black outline round the figure, making it look as though outlined in black paint. This plan, when skilfully used, has a most striking effect. A similar result is attained in basse-taille by the greater depth of the enamel round the edges. The colours were melted all over the work, no partitions of gold being left visible. The whole was then ground and polished. The effect is exquisite. The colours employed were a beautiful transparent red made from copper, or perhaps from gold, yellow from antimony or silver, violet from manganese, steel-grey (manganese mixed with cobalt), and blues and greens of cobalt, copper or iron.

There are some specimens of this work at South Kensington, and a small one is also in the Wallace collection. There is a set of six scenes from the life of Christ in the Louvre. Each plate is circular, and about two and a half inches in height. They were no doubt used as ornaments for a reliquary. The drawing is rather archaic, being in the style of the Flemish masters, who had so great an influence upon French art; but in execution, colour, finish, and artistic feeling nothing better can be desired.

With the exception of one or two dents on the edges, they are as fresh as though they were not

twenty years old. Indeed, as one looks at them, it is impossible to realize that they were done at least five hundred years ago. It is hardly too much to say that these six modest little plates, which a casual visitor at the Louvre might pass by without notice, are, from an artistic point of view, better than anything that has been put out by all the porcelain and enamel factories of Europe for the last two hundred years.

Whatever faults Gothic art may have had, its aim was always practical. It was not practised as art simply for art's sake, or for the mere enjoyment of it apart from some use. In the days when few could read, the common people learned Bible history and the lives of the saints from church windows and pictures. Similarly the emblazoned shields of knights and the painted signs over shops in old days were for the benefit of the unlettered. It was to bring these scenes more vividly before the ignorant that the dress of the figures in representations of sacred subjects was made like the dress of the day, or at all events only such changes were introduced as would be understood by the vulgar. The greatest pains were taken to tell the story effectively, and to make each actor clearly perform his part.

For this reason either the names of the characters were painted near them, or else each was represented with some conventional attribute. St. Peter carried his keys and papal mitre, St. Paul a sword, St. Catherine a wheel, the risen Christ almost invariably bore a banner with the Cross. It was quite in accordance with this educational aim that two or three representations of different stages of the story should appear in the same picture. The strict unities

of time and place that cramp modern pictorial art, and that cramped dramatic art till they were fortunately rejected, were not observed, so that Abraham and Isaac were painted going up to the mountain in the same picture in which the sacrifice was represented at the top.

The didactic character of mediæval sacred art is very clearly seen at Amiens, where the cathedral is covered with a systematic series of representations of Biblical history. The painted glass in most French cathedrals was also upon a similar plan. The painted glass in the church at Fairford, Oxfordshire, is arranged so as to tell the story of Christ from His birth to His final coming again in glory to judge the world. Until the Renaissance, ecclesiastical art was generally very highly symbolic. The twelve prophets were considered as types of the apostles, and every legend was invested with a mystical meaning. Those who desire to see how far the use of parables can go, may with advantage consult that curious storehouse of old tales known as the *Gesta Romanorum*. The Roman ritual is entirely symbolic from beginning to end.

In their desire to offer what was precious to the service of God, mediæval Christians delighted to fix jewels in gold mountings upon the picture, either studded upon the robe of the Virgin or on the breasts of the saints. In early enamels these jewels were represented by dots of gold and coloured glass. The custom of dedicating gold and jewels to church use is now obsolete; indeed, we now use little for our churches but distemper in stencilled patterns and cast brass ornaments, the whole work being done by

contract by some tradesman. Sometimes, to keep up the illusion, we give to the figures the staring eyes and rigid drapery of Byzantine times. These miserable imitation fossils of bygone ages are the astonishment of the poorer classes, who wonder why the artists who decorate churches draw so much worse than the pictures in the penny illustrated papers. But to appreciate Byzantine and Gothic work it is necessary to enter into the spirit of those who valued relics, and subscribed great sums of money to make shrines for them, and even fought battles for their possession.

The development of secular thought, which had been going on during the whole period of Gothic art, received a fresh impulse and a new direction in the fifteenth century by the arrival in Italy of the Greek refugees who were driven from Constantinople by the Mohammedans. The revival of classical learning gradually drew the arts away from the service of religion, and applied them first to the pomp and ceremony of civil life, then to its pleasures, and lastly to the gratification of luxury and the stimulation of debauch. The spread of the new movement was enormously quickened by the invention of engraving upon wood, printing with movable type, and engraving upon metal. The art of the Netherlands during the fifteenth century profoundly affected that of France, and Paris in its turn reacted upon the Netherlands. It is somewhat difficult, in consequence, to distinguish French from Belgian art of that period.

Germany also, especially through the works of Schöngauer and Dürer, exercised a strong influence,

the signs of which are very perceptible in the printed books which replaced the hand-painted missals formerly in vogue. The pictures were frequently painted with colours, and gilded sometimes with great taste and elegance. The high lights were usually touched in with gold, and the influence of these books can be very distinctly recognised on work in enamel.

But towards the end of the fifteenth century the public, though still under the domination of Gothic traditions, had imbibed a considerable amount of Renaissance taste and feeling, which manifested itself in a desire for a more free and natural style of drawing. There therefore arose a demand for fresh work in enamel, more in accordance with the new style of art that was gradually gaining ground. In response to this demand, a totally new mode of enamelling was invented, derived partly from the jewellers' work of the day, partly from the art of glass window painting. It is not clear where this invention was made, but it seems to have been introduced simultaneously in Italy, in Germany and in France.

The new method consisted in covering thin plates of metal with layers of coloured enamel, no longer melted into the recesses of cloisonné or champlevé, but made to flow over the whole plate or parts of it, and in gradations of thickness, whereby gradation of tint was obtained. The town of Limoges again took the lead in this manufacture, and retained its supremacy so effectually, that this sort of work is known as "Limoges enamel." It seems certain that the members of the Penicaud family who practised the art of glass painting were the first to execute this new work in Limoges. They took as their models the coloured pictures

which adorned the breviaries of the day, and which were in the Flemish style, with French influence.

"Nardon" (that is to say "Leonard") Penicaud was apparently the eldest of the family. His method was—having covered a thin plate of copper, or bronze, with a layer of opaque-white enamel—to paint, with a brush or pen in dense black upon the surface so obtained, a picture in strong outline, so as to resemble one of the coarse, strongly cut wood-cuts of the period. This was fired to melt the surface of the enamel, and fix the black outlines much in the same way as a black print upon a piece of china. To do this the charcoal furnaces then in use by glass painters were no doubt employed.

The next step was to cover the drawing with layers of transparent enamel, much as one would colour a wood-cut with paint. Nardon used five transparent colours, namely, two shades of saffre (cobalt), turquoise made from æs ustum (oxide of copper), grass-green from crocus martis (iron), and violet from "peridot" or that form of manganese ore which is found near the town of Perigueux in the vicinity of Limoges.

There appears to have been no transparent red among the colours used by Nardon, except small buttons of ruby placed upon little spots of gold leaf to represent jewels, and which were freely sprinkled over the picture.

For flesh, a reddish tinge of violet was used. This was done by painting the faces with a strong tint of violet, made from manganese and iron, and then, after this was fired, working over it with opaque-white in gradations, so as to let the violet ground show through

in the thinner parts. This work was called "grisaille," being the name then employed for white shaded work in painted windows. A thin glaze of violet was sometimes then put over the grisaille.

Metallic gold was lavishly used by Nardon Penicaud, though, owing to the imperfect way in which it was fired, a great deal of it has been rubbed off in the specimens of his work which we now possess; probably he used borax with it, a fatal practice. Not only was this gold painted in on the high lights of the drapery, but it was dotted in stars over the sky, or in curling ornaments or tongues of fire over the backgrounds.

He used red oxide of iron, that is to say, ordinary rouge (crocus martis), to represent blood, and sometimes upon the lips, but he did not employ this rouge otherwise. The principal tone of the colouring is cobalt and turquoise. The effect is most rich and harmonious, though the peculiar purple tone given to the flesh by the violet underground somewhat mars it.

There is an indescribable charm about Nardon's best work, due to the fresh and ingenuous expression of the faces, and the skill with which his simple colours are contrasted and united. The gold also gives delicacy and richness, and as the designs are usually taken from the very best work of the great Flemish masters, the composition is generally excellent. His most famous successor was "Jean."

It is not known what relation Jean Penicaud was to Nardon, probably a brother. He is sometimes called Penicaud II. in the catalogues, sometimes Jean Penicaud III. His style resembled that of Nardon, and

Triptych Centre Panel, by Nardon Penicaud, in the South Kensington Museum.

he used the same colours. The general tone of his work is no longer blue, as in the case of Nardon, but a more natural combination of various colours tending to a rather excessive use of a brownish yellow, a fault that is still more exaggerated in his successors. In his work transparent grounds for the first time appear, the copper being sometimes covered over with a layer of transparent glass, on which the design is drawn in black, and fired, and then covered in parts with grisaille, then with coats of colour, and finally again with grisaille. Jean Penicaud II. used paillons largely, that is to say, he placed gold leaf about the thickness of tissue paper on the enamel, fired it until it adhered, and then placed other coats of transparent coloured enamel over all. This mode of ornamentation had been known for centuries to the makers of glass goblets. Sometimes he shaded the grisaille, not by gradations of thickness, but by line-shading, made with a steel point in the layer of grisaille before firing, which caused the dark ground on which the grisaille had been laid to appear, and gave an effect as of etching.

He occasionally covered the whole plate over with gold leaf, so as to gild it completely. Upon this the design was painted in black, then tints of colour, and finally grisaille over all. There is a fine work of his in this style in the Cluny Museum at Paris. His skies are usually deep blue in the upper part, shading down into turquoise at the horizon, with small clouds or gold stars flecked over them. The same violet tones are used for flesh as in the work of Nardon. Sometimes, but rarely, there has been a little stippled shading to help the effect. The immoderate use of

paillon grounds by J. Penicaud II. has often greatly injured the stability of his work. Fortunately, the gold was beaten badly, so as to be in holes in some parts, and thus cause stronger adhesion.

The work of this artist is not well represented in the Louvre Museum, but the Museum at Cluny possesses some excellent specimens. At South Kensington there is a splendid series of enamels, representing scenes from the life of Christ.[1] These, if carefully studied, disclose the whole art of enamelling. There is hardly a single process or artifice with which the artist was unacquainted. The admirable manner, too, in which he has used the six colours he possessed, so as to produce variety, and yet avoid a patchwork effect, is quite a lesson in colour composition. His work shows that he has been strongly influenced by the Renaissance movement, but not to the entire destruction of Gothic feeling. It is a source of satisfaction, in comparing our modern enamel colours with those of Penicaud, to be able to say that in brightness and clearness the modern are decidedly superior, and that not one of the old but can be imitated and surpassed. Unhappily, the artist who compares one of his own attempts with the beautiful work of Penicaud will be obliged to admit that the fault lies in himself, not in the materials. There were no doubt contemporary artists whose names have not come down to us, and who followed their style, but in a very inferior manner. The characteristics of these imitators were a larger use of grisaille in the high lights of the drapery, and a variation of colour by the superposition

[1] One of these is reproduced in the frontispiece.

One Wing of a Triptych, 16th century, in the possession of Mr. Morland.

of one tint upon a different one, as blue upon violet. They also unduly introduced yellow, much to the disadvantage of the effect.

The specimens of early Italian enamel that remain are so rare as to be incapable of classification. There are one or two in the collection of Mr. Salting, and four beautiful plates in the British Museum.

They are usually executed on a ground of transparent cobalt-blue, laid on flat silver plates, often stamped into patterns to afford a firmer holding for the enamel; but sometimes paillons are used, covered with ruby.

The grisaille, instead of being shaded off in washes as in French work, is most delicately stippled in, looking like exquisitely fine chalk-lines. The colours are superb, and in the best style of pre-Raphaelite art. The fact that they were usually executed upon silver no doubt has led to the destruction of most of them by the bands of robbers who, under the leadership of the Sforzas and other soldiers of fortune, pillaged Italy, destroyed her art, and finally handed her over to the despotism of Austria.

During this period, that is to say, the end of the fifteenth century, there seems also to have been executed some of the work known as plique-à-jour. This is done by forming a number of cloisons without any foundation, so as to resemble a sort of grating, into the interstices of which enamel was melted. The effect is that of filigree work, filled up with variously coloured transparent glass. Very few pieces have survived. In the life of Benvenuto Cellini, he relates that Francis I. showed him a specimen, and that he imitated it. There is no difficulty in this work, the

method of which will be described hereafter. It is done to a limited extent at present in Russia, but genuine old specimens are exceedingly rare. Work in this style is executed in Geneva and in Sweden.

The progress of enamelling which has been above described carries us well into the sixteenth century. But a great change was at hand. Under the influence of the revival of classicalism, and in the hands of Carpaccio, the Bellinis, Botticelli, and Leonardo da Vinci, painting assumed the most exquisite forms. The Florentine architects infused the spirit of classical ornament into Lombard and Gothic architecture, so as to produce a new style, of which the scuola ot St. John the Baptist at Venice or the tombs of the Scaligers at Verona are examples. In the hands of Ghiberti, Donatello, and Lucca della Robbia, sculpture and modelling rose to new forms of beauty, while the genius of Michael Angelo crowned the work by his majestic creations.

If the influence of the classical movement had stopped here, it would have been productive of unmixed good, and might have resulted in a new and beautiful style, which would have gone on developing for centuries. Unfortunately, however, the taste for classical learning passed due bounds, and took such a hold upon art as to destroy its vital energies. Classical history or fable almost monopolised the subjects of pictures; classical costume became universal. Madonnas were made to resemble goddesses. The dignified angels with prismatic wings of the fifteenth century gave place to infant cupids. If the nude was to be represented, artists could think of nothing better than the Judgment of Paris, or

Perseus and Andromeda, or the chaste Lucretia, who was frequently represented as having prepared for death by divesting herself of all her clothing. The judgment of Solomon, and the history of Susanna, afforded subjects for courts of justice; the Queen of Sheba coming to Solomon flattered the vanity of a pope or a prince—all, however, being in classical costume.

In desperate endeavour to give some modern interest to this hack-work, it became usual to put the heads of the patrons of arts, on the bodies of Æneas, Julius Cæsar, or Alexander; and where modern battles were painted, the combatants were represented either naked, or in the dress of Roman soldiers.

Thus began the reign of pedantry, in which art was admired, not because it gave pleasure or profit to the spectator, but because it afforded an opportunity for the display of classical learning. For what interest could the ordinary mind take in such scenes? Who cares about the birth of Venus, or the rape of Europa, except as a means of displaying beautiful nude figures? How wearisome, even when done by the greatest artists, appears the well-worn "Fame" upon a tomb, with a trumpet and a wreath of laurels, or "Patience" upon one side of a monument smiling at "Grief" upon the other. Such art as this was deficient in soul. It had ceased to draw its inspiration from the social or religious life and feelings of the people. It appealed no longer to the masses, but only to a group of illuminati. Its roots were severed from ordinary human pleasures and aspirations, and its death became only a question of time. It died hard, poisoning by its corruption the art of all Europe, and ending with death-

heads and skeletons on tombs, grinning satyrs, stone clouds, empty niches, pot-bellied Pompadour furniture, and scrolls of fame, with nothing inscribed upon them.

Unfortunately for France, the Renaissance, instead of being allowed to exercise a gradual influence, was introduced suddenly and in its worst form by Francis I. If he had only patronised Leonardo da Vinci and Benvenuto Cellini, nothing but good would have resulted. As it was, architecture in his time kept clear of the worst Renaissance influence; but, unfortunately for painting, on his release from captivity, he persuaded Rosso and Primaticcio, two pupils of the school of Giulio Romano, to superintend the decoration of Fontainebleau. Both, especially Rosso, were men of more than mere talent; but they brought with them the whole paraphernalia of faded classic allegory. In consequence, Dido and Æneas, Diana and Actæon, Venus, Hebe, and the kindred tribe of hackneyed goddesses, sprawled upon clouds, over wall and ceiling, in France for three hundred years. In 1764, we find Cochin representing the Goddess of Medicine interfering to prevent the Fates from severing the thread of life of Madame de Pompadour. They are all upon clouds with music, painting, and sculpture, the arts which Madame de Pompadour patronised and did so much to degrade, scattered about in the smoke, as if shot out of a volcano. Or again, we have Louis XV. as Apollo, dispelling the mists of infidelity and ignorance. The movement only ended with the introduction of the modern romantic schools.

Rosso and Primaticcio were surrounded by a number of engravers, among whom Etienne de Laune,

who engraved patterns for jewellers, was especially followed by enamellers. The engravings of Marc Antonio, who made bad copperplates from Raphael's designs, were also much used.

Portraiture suffered less from Italian influence than subject painting, for, in spite of some exceptions, commonplace people insisted upon being painted in their ordinary costume, instead of being dressed as Venuses or Cleopatras. Cluet and several of his followers therefore remained faithful to the traditions of clear colour, modesty, and restraint, and served as admirable models for the portrait-enamellers of the sixteenth century.[1]

The effect of the Fontainebleau school upon enamelling was only gradual. During the early part of the sixteenth century the influence of the Netherland and German masters still continued, and Schöngauer, Albert Dürer and Lucas von Leyden supplied patterns, especially for sacred subjects.

The most remarkable of the enamellers who adopted the new style was Leonard Limousin, that is to say, "Leonard the Limousin," possibly so called to distinguish him from Leonard Penicaud, or from Leonard Tirny, a distinguished engraver of that epoch. Leonard possessed real talent, and in order to retain his services Francis I. gave him the post of one of his

[1] Just as the Gothic artists had represented the Roman soldiers at the Crucifixion in French or German costume to instruct the vulgar, so the Renaissance artists, with equal anachronism, but less excuse, put modern soldiers in Roman dress to please the savants. Benjamin West was the first artist in England to break the tradition, in his picture of the death of Wolfe. Talma, the French tragedian, first abandoned classical costume in tragedy after the taking of the Bastille.

valets, and assigned him a small salary. He worked in every conceivable way. Sometimes he put transparent ground on the copper, sometimes opaque. He rarely used a black ground, except for portraits, and the black outlines in his enamels are usually painted with a brush. Like his predecessors, he had a limited number of colours. In the high lights, instead of putting white grisaille work under the colour, he put it upon the top, which gives a chalky appearance. One is bound to admire many points in his drawing, and, considered simply as an artist, he was the greatest enameller of his day. But his work is often very bad in colour, and frequently exhibits the absurdities and trivialities of the Italian school without its merits. Perhaps one of the reasons why his enamels appear tedious is the constant recurrence of muscular Roman centurions in yellow and blue, with helmets, cuirasses, tunics, bare legs, and sandals. He also caught some of the worst tricks of posing and posturing, and impossible undulations of the body, which distinguish the Italian decline.

There is, however, one department in which he easily occupies by far the highest position, namely, portraiture. His portraits were painted from drawings or pictures of excellent character. These he sometimes copied on a background of black enamel. The face is put in with thick white grisaille, over a coat of black, and painted up with fine stippled opaque-red colour, made from rouge. The clothes are generally shining black, touched with gold, or else with unglazed black. The background is almost invariably of cobalt-blue, laid over a coat of white. The white enamel used to represent the skin is of the colour and appear-

Mc Lagan & Cumming, Edin. Ada Hunter.

PORTRAIT OF JEANNE DE GENOUILLAC BARONNE DE RHINGRAVE.

Salting Collection.

ance of egg-shell, with a low polish. The general tone is whiter than is natural. The eyes are usually scratched out of a dark background, but the mouth and other lines and wrinkles are painted upon the white. The clothes are often shaded in lines scratched through to a dark underground. The delicate white appearance of the skin gives an air of great distinction to the portraits, and harmonizes with the black and blue of the dress and background, which fuller colouring would have failed to do. Sometimes a high colour is given to the cheeks with oxide of iron, the tint being dabbed on with a fitch, instead of being stippled. The hair of women is almost invariably auburn, inclining to red, which, however, is accounted for by the fact that the Court ladies of the period wore wigs of this colour over their natural hair.

These portraits are suggestive in the highest degree, and this is a great merit. For with enamels it is impossible to attempt actual imitation of nature. The subject can only be suggested, not reproduced. And therefore, in an art in which so much must of necessity be left to the imagination, we most highly admire the skill of the man who employs the means at his disposal, not in a futile attempt to reproduce nature, but in an effort to give rise to ideas.

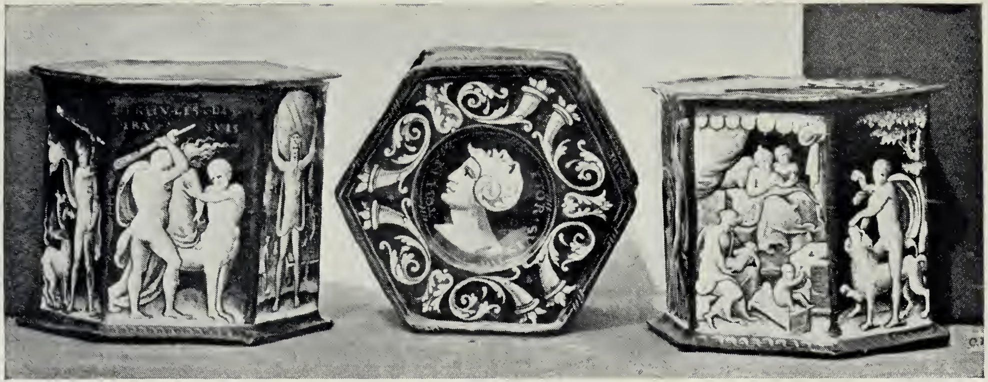
There were several successors both to the Penicauds and to Limousin, and a cloud of inferior imitators; but their work calls for no special mention. It was chiefly in grisaille upon black grounds, sometimes slightly tinted, and quite wanting in the noble colour of their predecessors. When colour was used, it was ill-arranged and glaring, and usually accompanied by an immoderate use of paillon.

Of these, Pierre Raimond occupies the first place. He seems to have possessed a sort of factory, in which all sorts of work, both bad and good, were marked with his initials. He turned out sets of plates, cups, salt-cellars, and candlesticks. The grisaille work is very beautiful when it comes from his own hand. He was skilful in the use of reds and greens, and his border decorations are usually very good. Some of his works in colour are also well harmonized. He does not appear to have executed original designs, and most of his patterns are taken from Renaissance artists. Sacred scenes he usually copied from Albert Dürer.

In the seventeenth century the art of enamelling underwent a distinct decline. The Laudin family introduced the use of white grounds, with pictures painted on them, in horrible drawing, and gaudy red and yellow, like painted earthenware. Raised work began to be used, by mixing china-clay with the enamel, and putting it on in lumps.

The atmosphere surrounding the court of Louis XIV. was not congenial to the higher forms of art. The king exercised the right of dictating to his workmen, and where Francis I. had been content to receive instruction, Louis XIV. covered the plans of his architects with his own corrections. As a consequence, every courtier claimed to be a man of taste, and art continued to decline until towards the end of the eighteenth century.

In the year 1730 the art of making porcelain was discovered in Europe, and this invention had considerable influence upon enamelling. Unfortunately, the first efforts of the china-makers were directed to



Salt Cellars in Grisaille on a black ground, in the possession of Mr. Addington.

imitating the costly Chinese tea-services, which were the pride of their possessors. The unhappy tendency produced by the desire to rival, if not to forge, the art of the Chinese has continued to our own day, and greatly vitiated the design of modern porcelain.

About the same time a new movement took place in thought, which is best represented in the works of Rousseau, Goldsmith, and Goethe, and may be summarized as a return from wigs and classical inanities to nature. It resulted in the Romantic Schools of literature and painting. In France it naturally partook of the character of the salon. Instead of real scenes of peasant life, such as Greuze painted, most of his contemporaries delighted to follow the lead of Watteau and Fragonard in their representations of dainty shepherdesses in court dresses and high-heeled shoes, with little washed sheep beside them with bows round their necks. This tendency was exhibited in china by the groups of figures executed at Dresden and Sèvres, and imitated and forged by the factories at Bow, Chelsea, and Derby, in England.

An exactly analogous effect was produced upon enamels, which now began to be executed on snuff-boxes and bon-bonières, on white grounds, with Watteau pictures of courtiers playing at pastoral life, surrounded by scrolls of rococo ornament. These were chiefly made at Battersea and Bow.

The salon art of the eighteenth century is not altogether devoid of artistic merit. Considerable skill is shown in the design, and the drawing is often very delicate; but it was pretty art, not great art. It was endurable when executed by artists, but it became wretched when it fell into the hands of hack

workmen, and when printed designs were substituted for hand work. This led to its abandonment. The factories at Chelsea, Battersea, and Bow were removed from London, and enamel upon metal ceased to be practised. And it was no great pity, for the noble art had now been completely degraded, and there remained only one more depth to which it could sink, which was attained when the mode of applying it to iron was discovered, and the walls of every railway station covered with detestable enamelled advertisements.

Meantime, however, there had been springing up a new application of the art in the shape of miniatures painted upon enamel and fired. This was only a development of the portraits of Leonard Limousin, but in style it resembled miniature painting. A splendid collection of such work is to be seen at South Kensington Museum. It was a perfectly legitimate branch of art. A large portrait is more satisfactory than a miniature, but a lover cannot take it into battle on his breast; and the desire for small portable portraits of our friends has given rise to a beautiful development of enamelling. The man to whom this is chiefly due is Petitot, a jeweller of Geneva, who migrated to Paris, where he executed a great number of most beautiful miniatures.

The process is simple. It only consists of painting with metallic oxides ground very fine and mixed with small quantities of glass, upon a ground of white enamel spread upon copper or gold.

Great patience is required with the work, and great experience; but it presents no insuperable difficulties, and is, of course, far more durable than portraits on

Grisaille by Pierre Raimond, A.D. 1559, in the possession of Baron de Rothschild.

paper or ivory. This art was also practised with success in England, and the copies by Bone of the works of Gainsborough and Reynolds fetched considerable sums. Fine specimens are to be seen in the Wallace collection.

The last thirty years have witnessed a revival of enamelling. Claudius Popelin, a Parisian amateur, wrote several books, in which he displayed considerable wit and literary power, but great ignorance of his subject. In Paris, under the patronage of the Town Council, classes were started about ten years ago, which have laid the foundation of an industry. Unfortunately, they have now been discontinued. The centres of the manufacture in France are Paris and Limoges. It has also spread to Vienna.

Buyers, as a rule, will give little for modern work. They like to be considered connoisseurs. With pride they tell you that "the old colours cannot be matched," and "the old secrets have disappeared"; and in proof of this I have once or twice been shown a piece which I knew to be a modern forgery, for the best possible reason that I knew who had done it. This desire to pose as "collectors" makes people ignorant of the subject expect to get a Jean Penicaud II. for say £15, when if genuine it would easily fetch £500; and curiosity shops are now full of forgeries, skilfully chipped and dirtied to pass as originals.

Very fair champlevé imitations of Gothic work can be got at Vienna, and also picked up in the curiosity shops, where they are sold as genuine. Everywhere, in Paris and in London, painted enamels really very nicely executed upon white grounds in the god-and-goddess style are to be found. They are mostly

goblets with gilt brass stands, or clock cases with real old watches let into them. £3 or £4 will purchase an excellent example of this pretty work. Copies of Battersea enamel may also be got, beautifully imitated, chips and all, so as to be quite indistinguishable from the originals. It is only great experience and knowledge of the particular forger's tricks that can detect the difference.

The truth is, that almost all genuine enamels have now found their way into museums and private collections, and certainty is only obtained by buying an enamel with a pedigree. Owing, however, to the many forgeries that have been perpetrated of pieces of the Spitzer collection, it is rash to rely on any piece professing to come from thence; and no one is quite safe unless he can be sure of a descent through private hands at least prior to 1860. As for the professions of an ordinary dealer in curiosities that he can detect forgery, I advise no one to believe them. There are very few men who can detect a really good imitation. This is highly satisfactory, inasmuch as it gives us assurance that we possess all the secrets of the ancients, and enables us to satisfy our love of art at a moderate price. If people would buy original work, or if they would only employ artists of talent to make really good copies of works of art instead of buying forgeries, in the vain idea that they have picked up wonderful bargains, a great improvement would take place both in the power of the artists and in the taste of the public.

Modern original work in Europe is very disappointing. The French seem universally to adopt an ugly chocolate brown as a ground, which gives the tone

Portion of a Dish by J. Courtois, after a design by Raphael, South Kensington Museum.

of a coloured photograph. In England, Mr. A. Fisher, of Warwick Studios, London, has produced some very beautiful pieces of tender colour ; his work always exhibits thought and knowledge of the principles of design.

In Geneva the art of miniature painting on enamels is practised with some success.

Japanese enamels are very fine cloisonné. They are delicate and well-executed, and, like all Japanese art, are of the decorative order. Although very pleasing as ornaments, they are apt to become wearisome, the subjects being confined to mere designs, to the grotesque, or to blocked-in outlines from nature. The colours are usually pale and opaque.

Chinese enamels are brilliantly painted in red, blue, and green, on white grounds. The mode of execution is exactly that followed by the Battersea enamellers. They are glaring, and very inferior to Japanese art.

Chapter II

ON THE CHOICE OF A STYLE IN ENAMELLING

IT may be perhaps permitted here to suggest certain leading characteristics which a good enamel should possess.

1. In the first place, the subject must be one that is worth representing, and must have some meaning. It is not necessary that its aim should always be moral or exalted, though, of course, the very highest art will, as a rule, be connected with, and try to express, the highest feeling. Inasmuch as the splendour and glory of colour has always been closely connected with religious ideas, enamel is peculiarly adapted for use in religious art.

2. It must next be remembered that each material has its own peculiarity, and the mark of good art is to adapt the subject to the material.

Cast iron has one use, wrought iron another, stone another, and clay another. Oil paint is capable of depth and gradation, water colour of purity and delicacy, ivory is specially fitted for delicate stippling, paper for broad washes of colour.

In enamel it is difficult to produce gradation or accuracy of tone, and there is great difficulty in the working. It has, however, two qualities that compensate for these defects, namely, durability, and a beauty of colour unapproached by any other known material.

These then indicate that where permanence and grandeur of colour are required, enamel should be employed, but that it is a waste of labour to use it for brush painting of small pictures or landscapes. Therefore, pale little painted Battersea enamels, surrounded with trivial ornament, are bad art. The great characteristic of the material has been lost. Enamels should be rich, and if possible magnificent. If they have this quality we can pardon defects in gradation, and in drawing, out of consideration for the difficulties of the work. For in enamel nature cannot be imitated; it is only possible to produce an effect by means of suggestion.

In some books upon composition, a great deal is made of the contrast of complementary colours. Thus it is asserted that red should be contrasted with green, and yellow with purple; but it is a mistake to attempt to make rules of this sort. There are of course colour laws, but they are not of this crude description. On the contrary, nothing is more beautiful than contrasts of the same colour in different shades. Blue and green make a splendid harmony.

There is, however, one observation I would submit, and that is, that if you wish to harmonize two colours that jar upon one another, it can usually be done by putting a little of each into the other. Thus, if the

paint for your wall does not harmonize with the paint for the dado, a few tablespoonfuls of each put into the other will often produce an excellent result; and enamels may be toned, either by a wash of some one colour over all, or else by washing a red and a contiguous blue, each with some of the other colour. They will then generally harmonize.

3. Our forefathers, among other intellectual legacies, have handed down an idea that it is a gentlemanly thing to know something about art. This unfortunate impression has produced untold evils; for too often every gentleman considers, like the Marquis in the comedy, that he knows all about painting without having learned, and is ashamed of that acknowledgment of ignorance which is the first step towards knowledge.

The inevitable result of this tendency is, that artistic opinions, instead of being formed slowly, with caution, and after the correction of many mistakes, are taken, either consciously or unconsciously, from the works upon art which happen to be in vogue at the time, and being assimilated, are mistaken by the possessor for his own conclusions.

In consequence, while believing himself to be forming original judgments, he is merely reflecting the latest artistic fancies.

At one time it will be all Corregio, at another the public will run mad on Burne Jones. One year the fancy will be for Reynolds and Gainsborough, another will see a furore for French so-called impressionism. And therefore, when it becomes no longer a question of admiring, or trying to persuade ourselves that we admire, certain well-known pictures, but of

choosing wall-papers, carpets, crockery, and furniture, having no principles to guide us, we fall into woeful blunders of taste.

This want of discrimination on the part of the public is very injurious to true art, for an artist must live, and few (at least of those who have families) have the courage to desert the art that pays, for the art that they know to be the best. Moreover, most things that are purchased, as for example wedding presents, are chosen with a view to get as much show as can be obtained for the money, and this purpose is served as well by a machine-stamped silver cup as by one which has been hammered out by hand. Therefore an enameller who is resolved not to be merely a hack workman is placed at a great disadvantage, for the true beauty of hand work consists in its absence of regularity, whereas the peculiar quality of machine work is its mechanical precision. The English ordinary eye, as at present educated, desires this precision. It loves precise repetition, such as a row of cast-iron railings. It loves to see each link of a watch-chain made so as to satisfy a micrometer-gauge, and each window of a house an exact copy of every other. It loves perfectly smooth surfaces and exact right angles; it is the art of a nation of engineers.

To give pleasure, it is however necessary that there should be endless variety springing out of ordered regularity. The various branches of the tree should be conformable to a general design, but each twig should be different.

Nothing is more fatiguing to an artistic eye than a row of spots or lines which are mathematically true.

It gets as tired of them as a horse will do of a Roman road.

This is the secret why enamels in which the curves and lines are all done by hand are so much more pleasant than when they are drawn by a ruler, and I would counsel the total disuse of all mechanical aids.

4. Enamel work should be original. By this it is not meant that copies of good work do not make fine enamels. All styles, especially all styles of ornament, are characteristic of their age, but they should not be copied or traced, but should be impressed on the workman's memory, and then drawn in freehand without a copy. In this way they will partake of his life, instead of being mummies. But it is most undesirable to try to be too original. Such originality as comes naturally is to be welcomed, but striving after it has the wearying effect of a person who is always trying to make jokes, and produces a sense of spasmodic effort which is destructive to art. It is given to very few to strike out a new line, and this power only comes at rare intervals.

5. And lastly, I would venture to call the attention of ladies to the pretty things they can make out of gold and enamel with no other tools than scissors, pliers, a few jewellers' files, and a spirit-lamp and blow-pipe. Such charming things as enamelled ships, birds, and animals, which were so beautifully done in the sixteenth century, and which we justly admire in the museums, are easy to make by the whitest of fingers in the most tidy of drawing-rooms. I have given some hints upon it in a separate chapter. There are some beautiful specimens in the British Museum

which may serve as a guide and inspiration. Thus in cloisonné work the artist has the advantage of choosing from Egyptian, Assyrian, Greek, Byzantine, Gothic or Renaissance styles, all of which lend themselves admirably to this work, and a simple method of embedding precious stones among the enamel will be also given.

Chapter III

THE MODE OF EXECUTING "LIMOGES ENAMELS"

THE first style that will be described is that known as "Limoges enamel." It is the most difficult, and consists, as has been said, of melting glass upon the surface of metals, without any cloisons.

It is sometimes practised upon gold, but more usually upon copper. The copper should be very pure, so as not to melt easily, and well rolled, so that it does not exhibit any blisters when raised to a full red heat. The best is got in Paris. What is known as "Swiss copper" is also good. For small plaques, not exceeding 6 inches diameter, the copper may be ·35 millimetre thick, or such that 1 square cm. weighs ·3 gramme (in English measure this is ·014 inch thick, and corresponds to No. 28 on the Birmingham wire gauge, and a square inch weighs about 30 grains); but considerable deviation from this thickness is allowable, and for larger plates the thickness should be proportionately greater. The plate must not be too thin, for then it is apt in the fire to become much bent and twisted. On the other hand, if the plate is too thick, the enamel is likely to fly. Some metals are more suitable for enamelling than others. Gold is the best, and copper and silver are

next best to gold. Platinum is not good, nor is nickel. Iron is fairly good.

The fact that some metals do not take enamel well has been sometimes ascribed to their expansion when heated, but there seems no ground whatever for this view. The linear expansion co-efficients of metals are as follow:—

Gold . .	·0000151	per degree	Centigrade.
Silver . .	·0000190	,,	,,
Brass . .	·0000187	,,	,,
Copper . .	·0000171	,,	,,
Iron . .	·0000122	,,	,,
Platinum .	·0000099	,,	,,
Glass . .	·0000088	,,	,,

Thus, though gold expands more through heat than any other metal, and in fact has a co-efficient double that of glass, it is the very best metal for enamelling; while platinum, the expansion co-efficient of which is very near to that of glass, is nearly the worst.

From my own observations I am inclined to think that the true reason why some metals cannot be enamelled is because of the air occluded in their pores, which on being heated is liberated and forms bubbles. This view is much strengthened by the behaviour of electrolytically deposited copper, which when covered with enamel gives rise to a quantity of bubbles. It also shows the soundness of the practice of well burnishing any metal that is to be enamelled.

I have succeeded in enamelling electrotypes of copper, but only by very prolonged heating. It is a pity they take the enamel so badly, for otherwise very beautiful work could be executed by this means.

By electrotyping with nitrate of copper, in the style advocated by Mr. Swan, more compact electrotypes can be formed, which take the enamel fairly well.

Limoges enamels are done upon plates which are curved convexly in the centre; a plate 4 inches square may conveniently have a rise of about $\frac{1}{4}$ of an inch high in the centre. Its surface should not be an even curve, but it should be more curved towards the edges. The reason of this is to make it strong towards the edges and give it stiffness.

Small plates, especially circular ones, are naturally of a stiff shape, and may be more uniform in curvature. In small pieces some persons turn up a slight burr round the edges. This has some conveniences, for it stiffens the edge, and serves as a ledge to prevent the powdered enamel slipping off the edge, a thing which is very likely to occur and which involves the necessity of "patching."

In order to shape the copper, the old enamellers used to place it between curved iron dies and strike it with a heavy hammer, thus stamping it into shape. The modern and more simple method is to rub it into shape with a burnisher. For this purpose a mould is provided rather bigger than will be required for the largest plate, and hollowed out concave on the lathe. It is made of a block of hard boxwood, or of several pieces of boxwood glued together, such as engravers use. Or an excellent one may be made of pewter, *i.e.*, a mixture of tin and lead. (For our purpose about equal quantities of lead and tin will do very well; this is a common sort of rather coarse plumber's solder.) It should be cast in a circular plate, about 1 inch thick and 9 inches

diameter, and then turned out in the lathe so that the section is a smooth true circle, and the centre about $\frac{1}{2}$ an inch lower than the edges. It is better to make the mould of soft metal rather than hard, because hard metal causes every speck of dirt to make its indent on the copper plate; but if hard metal is used, a soft piece of calico or thin chamois leather may be put over it. A piece of beechwood covered with

Burnishing a Plate into shape with a hæmatic burnisher upon a concave block of wood.

brown paper will also serve. All that is wanted is a smooth, uniform concave surface for the plate to rest upon.

The plate is now cut to shape with a pair of shears or strong scissors, the corners are clipped off, removing little triangular pieces about $\frac{1}{8}$th of an inch in size, and the plate is then heated to redness and plunged into weak nitric acid and water (say $\frac{1}{8}$th of

nitric) to anneal (that is to soften) it and remove the scale. The plate is then well scrubbed with water and some fine powder, such as bath brick, or powdered pumice stone, to clean it. It is then dried and placed on the mould and burnished. The burnishers used are of hematite; good large ones should be used—the bigger the better. The stones should be well fitted into brass ferrules on the handles.

A flattened one somewhat like that in the sketch is very convenient. A very good one may also be made out of a piece of bent steel wire, with the part *a*, *b*, curved about to the curvature of the mould. It should be hardened, slightly tempered and polished on a leather with emery and oil, finishing it almost dry with fine emery.

The plate being on the mould, even rubbing all over with a pressure of say some 15 lb. or so will soon burnish it into a smooth bossed form like a watch glass. The curve will, if the plate is much rolled, become much smaller than that of the mould, but judicious working on the edges as well as the middle will result in the obtaining of any degree of convexity or concavity that is desired. About 3 or 4 minutes quite suffice for this operation, and once or so during the burnishing the plate should be annealed, for copper, silver and gold when rolled or rubbed become hard and resilient (or springy), whereas annealing renders them soft again.

Annealing is nothing more than raising the metal to a dull red heat. It is best done by putting the copper or silver plate upon a thin bed of charcoal, placed for convenience in a small frying-pan, and then heating it with a blow-pipe having a wide air-hole

and a good supply of air. A mouth blow-pipe will do, but a foot one has more power. The plate should be evenly heated all over and then suddenly plunged into water; when this has been done the copper should appear as soft as lead, with no spring in it. Gold is annealed by heating, but should not be plunged into water, for this makes alloyed gold brittle. Instead of charcoal, the plate may be placed on a matted, tangled

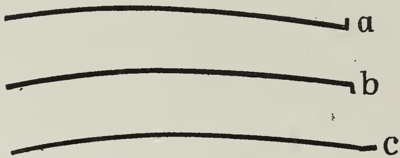
A simple form of Burnisher, made of steel.

mass of iron wire, or on a bed of fire-clay, or on asbestos fibre broken up, or else simply held in the pincers; but it is best to do it on charcoal, as a more regular heat is obtained.

As soon as the plate is made convex the corners and edges have to be attended to. In the first place the corners should, with a smaller burnisher, be made a little more convex, and the edges also con-

vexed a little all along. The edge may be made of several forms, as at *a*, *b* or *c*.

If *a* is adopted the part turned up must not be more than $\frac{1}{30}$th of an inch wide—in fact only a very narrow ledging, little more than a mere burring up of the copper. It is done by laying the plate on a sharp metal edge, and allowing it to project about $\frac{1}{20}$th of an inch over the edge, and then rubbing the edge over with a burnisher. If too wide in any part, it may be filed down. We have now got the plate formed. The next thing is to see that the bottom



Various forms of Edging for a plate.

edges are quite true and level. If laid on a piece of flat glass there is every probability that the corners will cock up in the air. If this is the case, it should be laid on the mould, and a few strokes of the burnisher, by expanding the metal in one place or another, will soon render it even. It is of no use to try to bend it even. The form must be given by expanding the metal by rubbing with the burnisher; for it is obvious that, as a flat piece of metal has been made into a sort of convex dish, the middle must have been rubbed thinner and made to expand more than the edges. With practice, a few touches with the burnisher will at once correct any plate. The plate must now be finally annealed, for if any spring

be left in it, it might fling off the enamel powder. It is now ready for cleaning. There are a great many ways of cleaning the plate: immersion in hot dilute nitric acid (1 part in 10), in hot potash solution, in hot solution of cyanide of potash (very poisonous). Any of these are good, but the best plan is to seize it by means of a pair of tongs whose ends are made of glass, and plunge it for an instant, till it just fizzes, into strong nitric acid. It should then be rinsed under a tap and put into a dish containing water to which some ammonia, say $\frac{1}{200}$th part, has been added, to clean away all traces of acid and grease. If this has been properly done the plate will look like highly burnished deep red gold, and may lastly be washed with clean water. Care must be taken to avoid the fumes of nitric acid, which are very poisonous. The dipping should be done in the open air, or under a chimney.

It is a good plan to scour the plate with a little pumice powder and water, but it is not essential. In fact there are a hundred ways of cleaning the plate, but the important part is to get off completely all grease and scale, and leave no dust or grains of copper clinging to it. No finger should now touch the plate, which if left in the air would become oxidized and greasy. I do not know why this is, but it is undoubtedly the case. Perhaps organisms fall upon it. It is certain, however, that the smoky, vitiated air of a room affects a plate, which ought to be coated and fired as soon as reasonably practicable after its last cleaning. For silver, sulphuric acid and water are employed instead of nitric, or weak hydrochloric acid may be used. It is best to keep the plate under

water till wanted, if any time must elapse between its final cleaning and use. For all operations filtered water is not needful; clean tap-water is amply sufficient. If the enamel that is to be put upon the plate is transparent or nearly so, and it is desirable that the reddish golden colour of the copper should show through, no more is done to the plate; but if it is to be covered with dark or opaque enamel it is better to remove the last trace of grease by exposing it to a temperature of about 400° Fahrenheit. This may be done over a lamp or Bunsen burner or in the drying cupboard, but it must not be more than enough to give the copper the peacock iridescent colour called "gorge de pigeon." If transparent enamel were put over this, on melting, it would dissolve the copper oxide, but would be apt to be tinged slightly.

We have now got to cover the plate with enamel. If the object is to make a Limoges enamel, the first coating will be black, or opaque-white, or clear transparent fondant,[1] or transparent colour. If the object be to make a "painter's enamel" plate, then it will be covered with opaque-white glass.

The enamel is now to be pounded up. For each 8 square inches of plate about 30 grammes (1 ounce) of enamel is needful to produce enough to give one coat.

The enamel is placed in a very hard mortar, about 8 inches in diameter, preferably of Scottish or Villon granite, with a pestle of the same material. A little

[1] The word "fondant" or "flux" is used for plain, white, transparent glass, this being the "foundation" of which all other colours are made.

clean water is poured on to it, to prevent the chips from flying, and then it is pounded into small pieces with the aid of a mallet. The mortar may be laid on a bag of sand to prevent its being broken by the shock. Afterwards the enamel is ground up with the pestle to the size of ordinary sea sand. Iron mortars are apt to give off chips of iron scale, and porcelain mortars chips of white porcelain, which when once in the enamel cannot be got rid of and cause specks. A magnet is of some use in removing the iron; the china chips must be picked out. Hard Wedgwood ware is fairly good, but still gives rise to chips. Scottish granite mortars can be made to order, but are rather expensive. They are, however, far the best.

A mortar 9 inches in diameter and 3 inches deep is very convenient. The pestle should have a handle 3 or 4 feet long, and the upper part passed through a ring fixed to a bracket, as was common in old-fashioned kitchens.

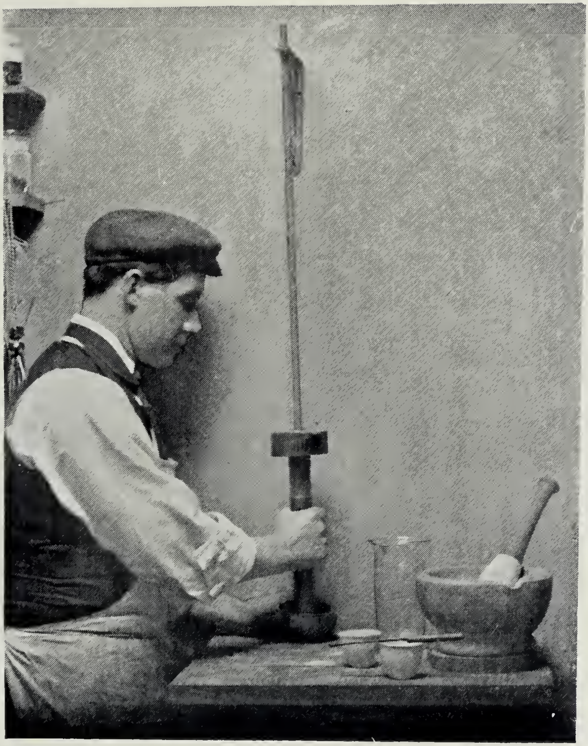
After the enamel begins to become small as sand, a milky substance seems to be disengaged and to fill the water which lies above the enamel. This consists of some of the colouring matter of very fine particles of enamel and of potash and soda. If any of it is left in, the enamel when fired will be opaque and dull. Hence it must be washed away by agitating the pounded enamel in water poured into the mortar and then pouring off the fluid. This must be done till the enamel remaining is in fine even grains, looking like a perfectly clear, clean, fine sand. The size of the grains may be such as will go through a fine sieve with meshes 75 to the linear inch. The grains

which will pass through this would thus be about $\frac{1}{100}$th of an inch in diameter. The material which is washed away will amount to about half the weight employed, and should be poured into a receptacle, and will gradually settle down into a grey mud. A plate covered with the clean clear enamel will, when fired, become transparent, but one covered with the mud will become of an opaque colour and not very brilliant on its surface. It will be good enough for the counter-enamel. The last part of grinding of the enamel should be done in an agate mortar about five inches in diameter with a pestle fitted into a handle from which a vertical iron rod projects, which passes through a hole in a bracket fixed to the wall. The handle should be loaded with a weight of lead of about 6 or 8 pounds.

The agate mortar should be supported on a cushion of cloth or placed in a box with some soft substance, so as to prevent being broken by an accidental blow. Of course after this the enamel should be washed as before. It is a good practice to add to the final washing water one drop to the pint of hydrofluoric acid, or else a drop or two of a solution of cyanide of potassium.

Some people recommend washing it with weak nitric acid, but this does not seem to improve it. We have now, out of 30 grammes (an ounce) of enamel, got 15 grammes of fine ground clean enamel, which will cover about 8 square inches of copper, and 15 grammes of mud. The latter may have the water poured off and then be dried in a basin put upon a sand bath, or else bottled up for subsequent use.

The reason why the mud becomes opaque when fused upon the metal is, I think, that a portion of the



Grinding Enamel in an agate mortar, with a pestle attached to a rod passing through a hole in a bracket, and loaded with a lead weight.

colouring matter is separated, and that the enamel becomes partly decomposed by the action of carbonic acid upon the alkali which it contains. The carbonates of soda or potash thus formed become, on heating, again decomposed by the silica, and minute bubbles of carbonic acid gas are formed.

This seems to be so from the fact that the mud washed away is not of the same colour as the residue which is left, but is of a dirty grey colour. If, however, the mud be heated in a furnace almost to the melting point of the copper on which it is laid, it will again resume its colour, for the heat reunites the decomposed glass, and the bubbles gradually escape. Opaque enamels need not be washed, except to remove any little dirt that may have got in, and, as will presently be seen, some coatings of enamel cannot be washed, but must be put on in a state of impalpable powder. So thin, however, are the layers thus used that they easily are fused up into transparent enamel. The powdered enamel thus prepared must be kept under water in small pots till it is wanted. If exposed to the air it rapidly disintegrates. Indeed, it will only last one or two weeks under water. If you wish to use old powdered enamel it is best to wash it with weak hydrofluoric acid, but by far the best plan is to preserve none of it, but to grind it up just as wanted, throwing the residue away.

We now have to deal with the method of spreading the powdered enamel upon the plate. This is usually done, and best done, with water; but there are certain weak solutions of gum which are indispensable for particular purposes. They are all forms

of mucilage, derived from various plants. They all contain a little resin, and on this account some of them are less soluble than others. Nearly all of them are best dissolved by being finely powdered and wetted with alcohol, before being put in water. The more usual forms are gum arabic (mimosa nilotica); gum acacia, the best and purest of the mucilages; gum tragacanth, a thorny plant growing in Greece and the East; gum senegal, which resembles gum arabic, but is more rich in resin.

Mucilage can be extracted from the pips of cherry, apple, pear, plum and other similar trees.

Mucilage is also found in various seaweeds, such as fucus crispus, and in Japan and China some seaweeds yield extraordinary quantities.

Among the forms of mucilage there is an endless field for experiment. What is wanted is a good tenacious gum, but which disappears as completely as possible when heated, and leaves no carbonaceous residue to spoil the enamel. Common dextrine, sold in bottles by the stationers as "gum" or "mucilage," is quite useless.

The following are a few of the best recipes for solutions of these gums:—

1. *Solution of gum tragacanth.* Wet 40 grains of it in alcohol, and grind it up till it is a thin paste, then stir it into a pint of warm water. It is most difficult to dissolve if not done in this way. (The corresponding amounts in French measure would be 4½ grammes of gum to a litre of water.)

2. *Solution of gum acacia.* 50 grains to a pint of water. (6 grammes of gum to a litre.)

3. *Solution of gum arabic.* 60 grains to a pint of water. (7 grammes of gum to a litre of water.)

4. *Decoction of sea moss* (fucus crispus). Gently warm 1 oz. of it in a pint of warm water. After it has soaked for an hour strain it off through muslin. (50 grammes of moss boiled in a litre of water.)

5. *Decoction of quince pips.* This is a very good solution; 1 drachm of pips should be soaked in a pint of water for forty-eight hours. The water may be gently warmed. (7 grammes soaked in a litre of water.)

To all the above add a drop or two of oil of cloves, to prevent them from becoming mouldy. Gum arabic keeps fresh; the others last two or three months.

Celluloid varnish. Dissolve 1 part (by weight) of celluloid in 800 of acetate of amyl, filter. This makes an excellent colourless cold lacquer for metals, especially for silver plate. If made much stronger, say 1 part in 100 of acetate of amyl, it will fix water-colour drawings so that no subsequent work on the drawing will loosen the undercoats. In fact it gives the drawing a coat of celluloid.

Solution of fat oil in benzine. 1 part of fat oil (*i.e.* the non-volatile part of ordinary oil of turpentine produced by exposing turpentine to the air in a shallow saucer), 200 parts of benzine.

The desirable characteristic in all the above solutions is that they should serve to stick the glass on to the copper, but when heated disappear, leaving the minimum of residue. Celluloid varnish and collodion disappear completely, leaving no trace behind. The others leave but little. Gum tragacanth is perhaps the best and simplest for general purposes.

The next process is to coat the back of the plate so as to form the counter enamel. There are a number of ways of doing this. The simplest is to paint some one of the substances above mentioned over the back of the plate, and then, while it is still wet, to powder it over with pounded transparent "fondant" (or flux). For this purpose nothing is better than a small tea strainer, made with very fine gauze. It should be about an inch in diameter. The plate is turned back uppermost on a small tripod placed in a tray, and gently peppered over by tapping the strainer. In this way a very smooth coat can be laid on. If it is desired to make the enamel adhere strongly to a vase or object of complicated shape, then very weak collodion, or the acetate of amyl solution, may be mixed with the dry powder, and plastered on with a small knife. When dry it will adhere admirably, and on firing leave no trace. The solution of fat oil in benzine may also be employed for the same purpose if used very thin. If the gum used is too thick, then on drying it will peel off, and on firing it will either make the enamel thick and gritty or else produce upon it in the firing a scum which will spoil its lustre. All this does not much matter on the back of the plate; but it cannot be too often insisted on that where practicable it is desirable to mix the enamel powder with nothing but pure water, or else with refined petroleum, as mentioned farther on. Or, if some adherent material is indispensable, then with one of the gums above mentioned. All these completely vanish in the firing. Sometimes in grisaille work glycerine and water are used, and sometimes a little sugar candy is added to the water, but such mixtures

are dangerous. It is said that the old enamellers used freshly made olive oil with success, but the oil obtainable in this country does not seem suitable.

As the powder is dusted on from the sieve, and falls on the wet plate, it becomes darkened in colour by the moisture. The process of powdering should stop while this darker colour remains, so as to make sure that the powder is all wetted with the solution and thus made to adhere.

Spreading Powdered Enamel on the face of a Copper Plate.

It is of the greatest importance that the enamel used on the back should be of the same character as that used on the front. Thus if an enamel, say of ordinary flint glass, is used on the back, it will cause an enamel of dense flint to peel off the front. And, as will presently be explained, it is very undesirable to mix enamels of different qualities together. It can be done with careful annealing, but it is dangerous.

It is also to be remembered that the thinner the

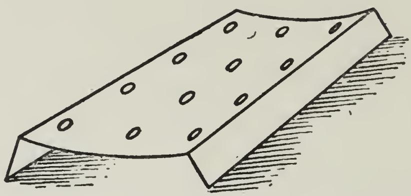
coats of enamel are the less liable are they to split or crack.

It now becomes necessary to coat the front with clean washed enamel. To do this a small piece of board, $\frac{1}{4}$ of an inch thick, should be provided. It should be just the size of the plate. A piece of clean dry blotting-paper is put upon it, and the plate is gently and dextrously laid upon it face uppermost, but so as not to disturb the coating on the back. The enamel mixed with water is now dabbled on to it with a camel's-hair brush. No gum or other stuff must be used, but only pure water. The excess of water may be removed with a small piece of linen, free from fluff, or else with a small piece of sponge fastened on a stick. By putting a dry rag near the edge of the enamel the water will be sucked off all over the surface. The rag, being then made into a tompion, may be gently pressed on the enamel, which, strange to say, will not adhere to it, but will be left in a semi-dry condition. It should now, by means of a stiff, well-polished iron or steel spatula, be spread over the plate. I find that a glazier's knife makes a good spatula; a flexible palette knife is of no use—you must have something hard and very stiff. When the enamel is just in the right condition of dryness it will spread like butter, and it must be spread *and thoroughly well pressed down* till it covers the plate in a perfectly even layer all over and *quite smooth.*

It is now ready for drying. Before it is dried, however, it must be placed upon the support upon which it is to rest in the furnace. In order that they may not bend, plates must be well supported, not only at points, but all along their edges, so that they

may not sag down when heated in the fire. It is not safe to leave more than an inch in length of a plate edge unsupported, and the question arises, what sort of support is best for it? Copper as a support is inadmissible, as on being heated it oxidizes, and spirts off little scales in every direction like fine rain, which cause green spots to appear on any melted enamel with which they come in contact. Iron is better. Fire-clay, if very thin, is the best. To prevent adhesion of the enamel the support must be painted over with rouge, or whiting, or tripoli-powder, mingled with water and dried. A mixture of equal quantities of pipe-clay and whiting with water is a good covering. Dry plaster of Paris dusted on out of a sieve into a very thin layer is also effective. The support should, if possible, be riddled over with holes, so as to let the heat get easily and quickly to the enamel. For the more rapidly it is got to a state of fusion the better will be the polish. For oblong plates, I find a sort of cradle made out of sheet iron of the shape shown in the figure very good. It should be coated all over back and front with rouge, or, better still, with equal parts of chalk (or whiting) and pipe-clay moistened with water and dried. This prevents the oxidation of the iron to a considerable extent, and the enamel will not stick to it. On this the plate is put, touching only along its two opposite edges, and having small wedges of iron pressed in at each end to support the ends, so as to prevent them from sagging when heated. If the plate is circular, a concave circular cradle may be used. The reason why the cradles are made concave is that only just the edge of the plate shall rest upon them. In this way

none of the enamel on the back is removed, for the edge of the plate rests at a sharp angle with the surface of the cradle. The plate is exposed in the drying oven to a gentle heat, say 100° F. or 120° F., for an hour. Do not try and dry it too fast, which will make it peel off; on the other hand, too slow drying would allow carbonates to form and spoil the work. If it is dried too long, say for three hours, or too much heated, say over 200° F., the adraganth or quince pips, or collodion, or whatever it is that has been used so as to make the counter-enamel adhere,



Iron Cradle for supporting a plate in the muffle furnace.

will be so baked as to become inadhesive, and the counter-enamel may crumble off.

As soon as the plate is dry, the enamel will look quite light-coloured, and not a trace of steam will come from it. Its dryness may be tested by holding over it a piece of cold transparent window glass, and noticing whether any moisture is deposited upon it—in fact, just the same plan as is adopted by prudent persons at an inn to see if the beds are damp.

The drying oven may be such as is ordinarily used by chemists for evaporation. It should be of iron, or of riveted copper. It should be capable of being raised to 400° F., or rather above the melting point

of ordinary plumber's solder. As has been said, enamels should not, however, be ordinarily dried at such a temperature. The oven should be ventilated so as to admit fresh air. It may be heated by means of a ring Bunsen burner.

Instead of a drying oven, it is simpler to lay the enamel upon a plate of stout iron, put over a Bunsen burner. In this way it is exposed to the draught in the room, and dries very quickly. Blowing on it very gently hastens the process.

It is not a good plan to dry the plates over the furnace, as one cannot see them. The heat is bad for the eyes, and there is a great chance that specks of soot will fall on them from the chimney. Each speck of soot will produce a spot, as will be explained farther on.

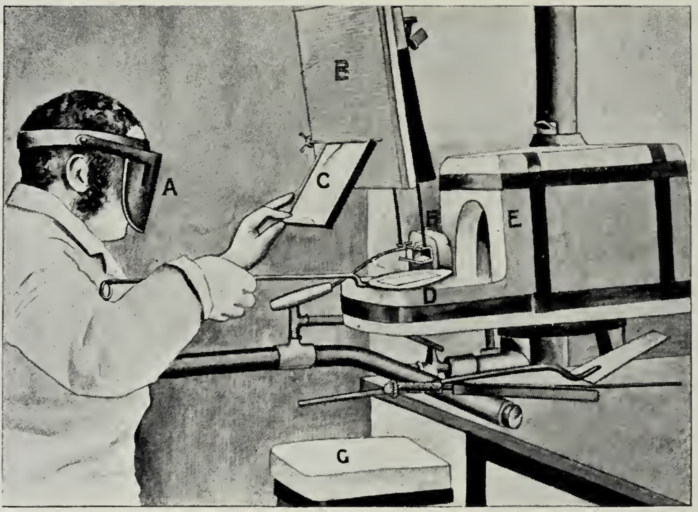
It is desirable to surround the oven with wood work, or put it in brick, for the radiation of heat from it is considerable, and very bad for the eyes.

The plate is now ready to be fired.

Throughout all the operations that have been described, the greatest care must be taken to avoid dust and dirt. The room is best without carpet or curtains, and if very dusty, the dust should be allayed with a spray diffuser and water. Dust will be found to come in great quantities from the operator's clothes, especially during the process of grinding. He ought therefore to wear a painter's canvas coat. Of course, all jugs and pots should be quite clean. Common blotting-paper, if used carelessly, is a great source of dusty fibre, and should never be pressed down on the enamel. The only proper kind to use is the dark-brown German bibulous

paper used for filter papers. The best rags and dusters to use are old linen rags that have been well cleaned. For pressing down the enamels, soft old cambric is excellent, and one or two rags should be kept for this, *and used for nothing else.* Some kinds of cotton are very full of fluff, and hence bad to use. Good glass cloths of linen are the best for general purposes. Every particle of carbonaceous matter is apt to produce a spot, by reducing the lead contained in the enamel to a metallic state. A small grain of sawdust will produce in the oven a pellet of lead like a small shot, for each bit of carbon is capable of reducing thirty-five times its own weight of oxide of lead to a metallic state.

The furnace used for heating the enamel should be a muffle furnace, heated either by coke or by gas. Gas furnaces of a very efficient character are made by Fletcher & Co., of Warrington. It is, however, quite easy for the enameller to make one for himself. There is no mystery about it. All that is needed is to surround a muffle with an outer shell about $1\frac{1}{2}$ inches clear of the inner one, and to introduce the nozzles of a number of Bunsen burners through the bottom of the shell. Great saving of heat is obtained by surrounding the furnace completely with infusorial earth, or Kiesselguhr, or by plastering it well over with non-conducting boiler composition. The furnace will consume from $\frac{3}{4}$ to 1 cubic foot of gas per hour for each square inch of floor surface of the muffle. The gas supply should be ample and the pipes large. It is advisable to make them larger than the sizes given by Fletcher. The heated air escapes through one or more holes in the roof of the furnace shell,



Gas Muffle Furnace.

A Mask.
B Screen of wood lined with iron.
C Swing glass door, to intercept the heat.
D A plate, on a fire-clay support, placed on a shovel ready to be put into the furnace.
E The furnace.
F The door, with a handle attached.
G A slab of fire-clay for resting the plate upon when it comes out of the furnace.

which are surmounted by short chimneys made out of iron pipe. They should not be too long, or else the draught will become too great, and they should be provided with dampers to regulate it. A long handle may be fixed to the furnace door to facilitate its removal.

A shield of wood, lined with iron, and a small swinging glass door are most useful in keeping the heat off one's face. They are shown in the drawing. Or else, to keep the heat off, a mask may be provided, made by attaching a large vizor, made of cloth glued upon thin cork, to the rim of an old hat. A large hole is cut for the eyes, and in front of it three pieces of thin glass are put, one over another, with spaces between each to enable the air to rise between the glasses and cool them. A large hole may be cut in the hat for ventilation. The mask should be light. If preferred, the vizor can be made of tin, and arranged so as to be raised up when not wanted. The vizor may be balanced at the back to prevent its being top heavy, so as to drag the hat down over the eyes.

Radiant heat will greatly injure the eyesight by drying up the moisture of the eyes. This makes the eyelids red. A little zinc and rose-water lotion will relieve them.

In case of accidental burns, some lint and a bottle of "Carron oil" should be kept at hand. The burned place should be well oiled with the "Carron oil," which is only olive oil and quicklime, and then held close to the furnace, so as to be heated as much as the pain will allow. This curious remedy seems well known to workmen, and I have found the benefit of it.

Never neglect a severe burn. By some curious nervous process a severe burn on a limb often causes inflammation of the intestines, or else a deep abscess. If blisters form, never prick them, but let them subside.

There is no difficulty in executing plates one or two feet square in a proper muffle furnace, and I have no doubt that in a glass painter's furnace plates of a much larger size could easily be fired.

To assist in putting things into the furnace and taking them out, tongs are needful. One or two sizes will do, also pincers like scissors, called in French "Moustache twisters." In addition to this, a bricklayer's trowel, dismounted from its wooden handle and rammed into a piece of gaspipe about two feet long, is a most useful tool. For smaller pieces a child's garden spade, or a large flat palette knife, is useful. A slender poker turned to a right-angled hook at the end is also serviceable. Among other things it serves as an object to be reflected from the surface of the plate, by means of which it can be seen whether that surface is glossy and sufficiently melted. A pair of housemaid's gloves of stout leather is also useful, for the hands are required to be perfectly steady, and hence must not be exposed to painful heat.

Some small plates should be provided to put on the bottom of the muffle; for if any powdered enamel gets on to the floor of the muffle, it will eat it through, besides causing everything to stick.

These plates may be made of fire-clay, mixed with an equal bulk of fine boxwood sawdust, and some water-glass, or else a little borax, well dried, and

then fired; or they may be of platinum if expense is no object, or of thin iron plate. In all cases they should be painted over with water mixed with rouge or whiting, or chalk and clay, or with tripoli. The two former, if any adhere to the enamel, may be dissolved off with acid; but tripoli (which is only *exceedingly* fine sand) will not dissolve in acid. Unless some such powder is put the enamel will adhere to the plate on which it rests. I prefer equal parts of chalk and pipe-clay, made into a thin paste with water. The chalk prevents the enamel adhering, the pipe-clay serves to fix the chalk to the support.

Cradles and plates can be also made by covering iron wire gauze with a thin layer of fire-clay, mixed with boxwood sawdust and a very little silicate of soda.

Take of dry powdered fire-clay . .	1 lb.
,, ,, boxwood powder . . .	¼ ,,
,, ,, thick liquid silicate of soda .	½ oz.
,, ,, water (a sufficiency).	

Put all together and let it soak for twenty-four hours, then work and beat it up into a uniform paste. It will do to mend furnaces or for any sort of work. If once it dries, the silicate solidifies, and it becomes useless. When it is heated, the boxwood powder is burned out of it, and, by "keeping the pores of it open," prevents it from splitting.

The next point is to get the furnace hot. This will take place in about twenty minutes if the gas supply is good. On no account should the gas supply be insufficient. The furnace and burners need occasional cleaning.

As soon as the muffle is at a full red heat, it must be cleansed from any sulphurous or carbonaceous fumes. This is done by blowing in air with a foot blower or a pair of bellows; for carbon and sulphur are deadly enemies to glass with much lead in it, and a drop of oil burning in the furnace will form a carbonaceous atmosphere which will cause a film of reduced lead to appear on the enamel. Subsequent heating and blowing upon with a bellows while in the muffle will, however, supply enough oxygen to oxidize the reduced film, and again restore the transparency.

If care is taken, very small enamels can be fired in the oxidizing flame of a large blowpipe, but they must only be an inch or so in diameter. They should be laid on a fire-brick, covered over with a thin plate of fire-clay, and the flame played on the top of the fire-clay vertically downwards. Indeed, a miniature muffle furnace can be made out of a crucible with the help of a large blowpipe, such as is used for brazing. The little plate is put on a piece of fire-clay, then into the crucible, which is placed so that it is on its side, with a cover on. Some bits of fire-clay are put round it to keep in the heat, and then the whole is heated up with the blowpipe. Cloisonné work can be simply done over a large spirit lamp with no muffle at all. A gas flame must not be used, as the sulphur which comes from it would blacken the lead glass.

If the covering of the plate with enamel has been very smoothly and beautifully done, the first firing should produce a good plate requiring little subsequent touching up; and this is desirable, for repeated firings tend to make the enamel shrink and to buckle up the

plate, besides leaving the edges bare; but if some spots or bare places occur, they should be cleaned by immersing the whole plate in acid, then well washing, and finally rubbing with pumice powder and a brush. They should then be patched up with enamel powder, and the plate fired again. If the muffle is clean and free from fumes, each baking improves its brilliancy.

During the firing, the enamel must be carefully watched. As the plate becomes hot, the enamel darkens and gradually appears as if it were sweating. This passes to an even, shiny coat, which will in the oven reflect brilliantly a piece of iron held over it. The artist should not be too anxious to get a very smooth coating at once; subsequent firings will gradually improve the surface.

Good work is usually *thin*. Thick coatings are liable to split. During the firing the plate, if at all nearly the size of the muffle, must be turned round once and put in again, otherwise the end nearest the door will be under fired.

With large plates, and indeed with all plates, it is a very wise plan to anneal them. They may be put into the muffle at once; but on being taken out, they should be left to cool slowly in hot sand. I have even used a sand bath, heated by a gas-light gradually turned down by means of a tap attached by a string to a clock. It took twelve hours to cool the sand, and annealed the enamels excellently. As a rule enamels will stand without annealing. This is because they are thin. By careful annealing almost any sorts of enamel can be laid one on another; without annealing different varieties are apt to crack.

The plate has now received its foundation layer, and is ready for the work.

First it will have to be determined whether any paillons or "foils" are to be used. If so, they must now be laid on. They consist of thin sheets of gold, silver, or platinum, melted into the surface, and covered with transparent enamel so as to be embedded. They give a splendid brilliancy to the superposed transparent enamel.

The thickness of metal suitable is such that a leaf of ten centimetres side should weigh half a gramme. This is about twenty-five times as thick as the thin gold used for gilding picture-frames. The gold must be absolutely pure. Excellent sheets can be got from the salesmen of dentists' material at about 4*s*. a gramme; that is, 2*s*. a leaf. Platinum is not sold by dentists' salesmen, but can be obtained for about 1*s*. 6*d*. a leaf.

To prepare the gold or platinum, each leaf must first be stuck between two sheets of gummed tissue paper, yellow being used for gold, and white for platinum, so as to identify them. The sheet must then be stabbed all over with minute needle-holes, right through paper and all. This is best done by sticking say 150 of the finest needles through a slice cut from a bottle cork, so as to project say one-quarter of an inch, and securing their upper ends with sealing-wax. The stabbing machine thus made is dabbed on to the gold enclosed in its paper casing, placed on a number of sheets of blotting-paper.

The shapes of the paillons are traced out on to the sheets of paper-covered gold, and then cut out with a fine pair of scissors. The figures cut out are now

placed in water, and the upper and under layers of paper allowed to float away. By this method all trouble in cutting the gold out is avoided. There should be plenty of holes—200 in a square inch are not a bit too many—and, if fine, they will ultimately be quite invisible. They are to let out the steam and air from under the paillon while it is being melted, and prevent the formation of bubbles of air or gas under the paillon.

The paillons may now be stuck in their places with some of the gum or adraganth-water mentioned above, and well pressed down with blotting-paper. Some people like them to lie smooth, some prefer them rather creased. In the first case the gold sheets as obtained from the gold beater should have been annealed, so as to be soft. It is in this condition the dentists use them. If, however, they have not been annealed, they will crinkle a little on being put on. The smooth paillon makes the most certain and workmanlike job, the other often gives fine effects. There is a gold used by dentists called "crinkled gold." It is gold all creased up so as to form a fine grain, like that of rough morocco leather. It produces a good effect as a paillon, and is quite safe, but it must be handled delicately. A good effect is obtained when it has been gummed on by burnishing a pattern on it with a burnisher. This pattern shines through the enamel, and may be made very effective for halos round saints' heads and in dresses, where the effect of bright burnished line work on a mat gold ground is wanted. It is also possible to stamp out small ornaments in gold, and stick them about, and cover them with enamel. For this purpose, however, the

gold should be thicker; about $1\frac{1}{2}$ grammes to the sheet of ten centimetres side does well for such work. Gold paillons may be used of large size, even covering the entire plate, provided only they are well pricked with holes and well fired. Platinum is not a good metal for enamelling, and platinum paillons are apt to be treacherous. Silver is safer than platinum, and more brilliant; but, on the other hand, it may melt and disappear in a very hot fire.

When the paillons have been stuck down and are dry, the next thing is to paint upon them such shading or lines as are needed. The best substance for this purpose is black sesquioxide of iridium. If it is to be used on an enamelled surface, it may be painted on pure; but when put upon metal surface, something must be employed to make it stick. An equal quantity by weight of flux (*i.e.*, dense white flint-glass) should therefore be finely ground up with it, with water.

The grinding is best done with water upon a slab of hard polished Scottish granite, with a muller of the same material; but a glass muller on a slab of plate-glass will do very well. The grinding should be continued till the flux and oxide are in a state of perfectly impalpable powder, and then dried. Iridium ready fluxed and ground can be bought.

The colour may be laid on either with thin gum water, or else with "fat oil" (that is, with turpentine exposed to the air till it has become viscid). This is diluted with oil of lavender, or with oil of tar. Both these substances are strong disinfectants. The glass painters who work with oil of tar are said never to catch influenza.

The gum water is the nicest to work with, but as the colour dries it becomes so dead that one can only with difficulty judge of the work, whereas with the lavender the strokes remain black and shining. A trace of glycerine makes the gum water flow more easily.

As soon as the shading and painting on the paillons and the surrounding enamel are done, the paillons must be fired, so as to be fused firmly down to the enamel. Judgment only can decide when the adherence is complete, but with pure gold and platinum a good firing may be given till the metal appears to be well glued down to the ground. This firing at the same time fastens down the black shading. Then, if needful, a second and reinforced shading may be given, and again fired.

The next step is to give the coats of colour. These are laid on in a state of moist powder, having been ground in the mortar and washed as before described. The colour is laid in patches where required, and where no colour is wanted a little clear flux is put on to keep the surface even. The thinner the layers are the better. With ruby reds the colour is finest when the enamel is not ground too fine. The enamel must be well dried with blotting-paper, and pressed and squeezed and smoothed down into an even surface, just as gravel is squeezed down by a steam roller. It must then be *most thoroughly* dried in the drying oven, for any trace of water left under the paillons will cause bubbles, and fired till the enamel has melted. If there are any uncovered spots left, they must be covered up, and the plate fired again. Colours that have been ground up on the slab with a muller will not do to lay directly on the metal; for, not being

washed, they will become opaque when fired, unless they are laid so very thin as to be useless for the first covering of the metal.

As a rule, blues and greens look best over platinum foil; reds, purples, yellows, and warm colours over gold; but in this matter there is, of course, no rule. All colours are beautiful if properly harmonized.

Silver foil is apt to stain the superincumbent colour yellow. If therefore silver is used, the fondant put over it should be of a very pale transparent blue, to neutralize the yellow stain produced by the silver.

The plate is now coloured, and the next step will be to consider how far the colours should be toned and harmonized. Even brilliant crude colours well arranged look beautiful, but it is often desirable to tone some one of them that is too pronounced.

This will be done by very thin washes of ground glass, in a manner to be described presently, and may often be done with advantage after the grisaille has been laid on.

By grisaille we mean a semi-transparent white, thin in some parts so as to produce shadows, and thicker where high lights are wanted. Great caution is needful in the selection of this white. What is wanted is a white which will fuse in the fire and become shiny, and yet will be so dense as not to be easily absorbed by the coating of enamel on which it lies. Flux with about 25 per cent. of white oxide of tin answers well, and is made as described elsewhere. It should remain unmoved, even in the hottest fire. With unsuitable grisaille the half tones will tend to disappear, and this is quite fatal to the effect. (See p. 131.)

There is considerable choice of practice as to how the grisaille should be employed. It must, of course, be ground up to an absolutely impalpable powder; but the difficulty is to choose the medium, for being heavy, it tends to sink in a light medium. Consequently, it is most difficult to use with a paint brush. All that can be done is to put it on in blobs, and then work it about into shape with a fine needle; but while this is being done the water evaporates, and if fresh water is added the enamel separates in a sort of scaly grit.

This suggests the use of some medium that will not easily evaporate quickly, such as gum or oil. In that case, however, a carbonaceous residue would remain in the enamel and reduce the lead. I have tried all sorts of gums and preparations, but none are satisfactory. Fat oil and lavender are not wholly unsuccessful. It is believed that the old enamellers used olive oil. I have not found it satisfactory, perhaps because what is sold in England as olive oil is generally cotton-seed oil. Glycerine mixed with water is also fairly successful.

Mr. Meyer, the French enameller, has proposed heavy paraffin oil, such as is used for lubrication, and is sold by Le Franc, of Paris, for use in oil painting. It remains liquid a long time; but at a temperature of about 180° Fahr. it absolutely evaporates, leaving not a trace behind. It is far the best, for all the other materials leave traces which spoil the surface of the enamel. If desired, some camphor can be dissolved in the petroleum, for camphor evaporates completely with heat.

Celluloid, dissolved in acetate of amyl, evaporates too quickly to be of service.

In grinding the white up, it must be powdered well in a mortar till it is almost impalpable, and then thoroughly dried, for, if mixed when wet with the paraffin, it will not work under the brush.

After it is ground to a perfectly fine smooth white paste with paraffin oil, it should be put into a covered ointment pot, or else into leaden tubes, such as are used for oil paints. Age does not deteriorate it. It may be diluted when wanted with paraffin oil.

Four or five successive coats of grisaille are wanted to give the full effect of it. It is not desirable to try and lay it on too thickly in one coat.

After each coating, the work should be dried off at about 200° Fahr. on a plate over a Bunsen burner, and then fired.

Italian grisaille is done by delicate stippling, the white being of an exceedingly hard and infusible character and mixed with fat oil and oil of turpentine or lavender. When fired, this white does not glaze, but remains dull like chalk.

In all cases where the oil of turpentine and fat oil are employed, the drying should be conducted with peculiar care, and the temperature gradually raised almost till the fat oil is blackened, before the plate is put into the muffle.

As soon as the grisaille is finished, the next step is the toning and tinting. This is done by covering such parts of the plate as require it with thin even coats of enamel, ground up with paraffin to an impalpable powder upon a slab of glass or of Scottish granite. Paraffin is much better for this purpose than water,

for the very fine state of pulverization of the glass causes the water to dissolve out of it a portion of the alkali. As the patch of enamel dries, the edges, becoming dry first, suck out the alkali-laden water, and thus by degrees a sort of border of alkali is formed round the enamel, like the ring of salt round a salt lake. This, when fired, becomes a dull stain.

This undesirable effect can be avoided by using a small knife of wood or ivory to scratch off about a sixteenth of an inch all round the border of the applied colour as soon as it is dry.

But the effect itself can be prevented by grinding up the colour in petroleum instead of in water, and this is the course I recommend. The colours must be very well ground, and when finished can be put into tin colour tubes like oil paints, or into small ointment pots, and being free from water will keep indefinitely. The most useful are flux, crimson of gold, and uranium yellow for flesh tints, cobalt blue, chrome green, manganese violet, and platinum grey. These six colours can all be mixed with some flux if needful to lighten them and put on in blobs, and then spread with a needle, dried and fired, and, by means of them, any enamel can be toned perfectly. But they must be laid on very thin, or else, being unwashed, they will become opaque and muddy when fired. An enamel, after having been executed as above described, is sure to leave much to be desired. It will appear strong in colour, but with a want of brilliancy and life. This last is added to it by the application of gold.

Gold is used with great effect upon hair, and upon the high lights of garments in a manner consecrated by long usage among miniature missal painters.

Sometimes it is put on in fine strokes with a very fine brush; sometimes in solid masses, scratched upon afterwards with a needle.

Two sorts of gold are employed. First, that produced by precipitation of the metal from the chloride by means of iron. To do this, take 1 gramme (15 grains) of chloride of gold, dissolve it in 100 c.c. of distilled water; put, say, 10 c.c. of the solution into a litre of distilled water, and then add a few drops of a solution of sulphate of iron. The gold falls in a brown powder; when it has settled, put in some more gold solution, and a little more iron, but take care not to have too much iron. When all has settled, decant the water off, and wash by agitating it with one part of hydrochloric acid in twenty of water, to remove the iron.

But better than this is simply to purchase gold powder, made by grinding up gold leaf on a slab with honey, and then washing the honey out. This is what is employed for shell gold. Indeed, shell gold answers very well. It may be put on with the following mixture:—

Water	15 cubic centimetres.
Gum arabic	4 to 12 grammes.
Glycerine	5 cubic centimetres.
Sugar candy	2 grammes.
Liquid ox-gall	5 drops.

A couple of drops of oil of lavender.

The gum makes it stick, the glycerine makes it flow, the sugar candy makes it viscous, the ox-gall removes the grease, and the oil of lavender prevents it turning mouldy. By increasing the glycerine to 15 c.cm., the gold pigment can be made to work as smooth as oil. In fact, it is almost too greasy.

Before the gold is put on, or painting done on the enamel, the plate should be well washed with methylated spirits, or with a little weak ammonia, or soda and water, and then dried with a very clean rag. Or else chalk and alcohol can be painted over it, and rubbed off when dry, just as photographic plates are cleaned. Indeed, any method may be taken that will get it perfectly clean. It is then dried and fired. The firing should be well and thoroughly done. A great deal of old work has been spoiled by imperfect firing of the gold.

Afterwards, the gold may be burnished with a small hematite burnisher wetted in a little beer; or else with some well-worn, fine-rounded sea sand moistened with a little beer. Both must be applied with caution. The date and artist's name may be put on in black or gold, or red iron lacquer colour, before the last firing.

The plate may also be reinforced, and spots taken out, with black enamel ground up and applied with fat oil and oil of lavender; or else oxide of iridium may be used with eight or ten times its amount of fondant,[1] so as to give a brilliant surface. After the last firing, it is always desirable to anneal the plate by putting it, while still very hot (say when it has just ceased to be red), to cool slowly in a mass of hot sand, or dry plaster of Paris powder.

The painted miniatures of Petitot and other artists are not done in this way, but are painted in colours upon a plaque of gold or copper, covered with white enamel. Colours for this sort of painting—that is to

[1] "Flux" or "Fondant" means white transparent enamel (see page 114).

say, for over-glaze enamel-painting—are divided into two groups, "vitrified" and "vitrifiable."

By vitrified colours we mean oxides of metals which have been thoroughly dissolved into, or else at least melted with, the flux. By vitrifiable colours we mean oxides that are simply mixed with pounded flux, and united with it by the heat of firing.

The first group of these colours—namely, vitrified colours—were largely used by the old miniature painters, such as Petitot and Bone. They are the best on account of their depth and brilliancy. They were also used by the painters on Battersea enamel. They are made exactly in the same way as enamels for Limoges work, except that in each case the dose of colouring matter is about ten times as strong. They are made both transparent and opaque. In some cases these colours, though called vitrified, are not truly vitrified, but only consist of the oxides melted into, but not dissolved in, the flux; as, for instance, iron red, copper red, and opaque chrome green.

Vitrifiable colours are made by grinding up the oxides with about three times their weight of flux. These colours flow more easily from the brush than vitrified colours, and in some cases are more brilliant. They are therefore much used for painting upon porcelain. The medium employed for painting may be either gum acacia dissolved in water, or else fat oil with oil of lavender or spirit of tar.

In every case, after the painting is done, it is a good plan to glaze over all with ordinary flux, ground up finely in water, and then to give a final firing.

For a flux for all these purposes, nothing is better

than common optical dense flint glass, as will be explained farther on.

This part of my subject touches upon porcelain painting, for, of course, with suitable fluxes, the processes are substantially the same. I will only say that the dense flint will go on to almost any porcelain as a flux; and in this way, small modern Dresden figures may be so beautifully touched up by a knowing hand that it is impossible to distinguish them from old ones. The marks of Dresden and other factories may in this way be added by any one who has a muffle big enough to hold them. The only precaution wanted is to take the greatest pains to anneal them. In this way, a poor piece of modern Dresden, if from the old moulds, may be made really very pretty; and if the artist is a liar, he may pass it off as genuine, or sell it as such if he chooses to be a cheat in addition.

M. Lacroix, of Paris, prepares vitrifiable colours ready ground in tubes, but I find that they get too dry to be satisfactory.

Greater ease of working for many sorts of work, particularly on faces, is produced by rubbing the surface over with hydrofluoric acid and water, so as to take off the shine and render the surface dull and easier to paint upon.

For cleaning the palette and brushes, nothing is equal to methylated spirit of wine. Brushes should always be cleaned before being put away. The cleaning of brushes clogged with old fat oil is facilitated by warming them.

Raised work is done by mixing together one part of flux and two of pounded china (broken common tea-

cups will answer very well), and then, after firing it, glazing over all with enamel.

Not much can be said upon the mending of enamels, except that it should be done with a very soft enamel containing plenty of lead, and therefore very elastic, and should be very carefully annealed.

Two precautions will be found useful. The first is to make a coloured drawing of the enamel, and settle not only all the colours, but before the work is begun to determine the mode of execution, and the order in which they are to be placed; of course alterations can be made, but a settled plan, thought out in all its details, should always be made.

For designing, I would advise first sketching the subject in charcoal on paper on a large scale, drawing in the outlines with a pen, and then rubbing in the colours with pastels. Such sketches may then easily be reduced on to the plate.

The second piece of advice is, when any plate is being executed that is at all of an elaborate character, to have at hand a trial plate, and to put the enamels on, and fire them in the same order as they are to go on the finished plate. By this means, if the arrangement is inharmonious, it will be perceived; and, moreover, if any of them do not amalgamate, but crack, they can be altered for others. The danger of cracking is, as will hereafter be seen, the great source of vexation in enamel work.

The progress of the trial plate should go on contemporaneously with the enamel, but one stage in front, each colour being laid on the enamel after it has been tried by firing on the trial plate. Of course the trial plate need not be drawn with care, and need

only roughly represent the enamel. If, however, it is finished carefully, it is possible to make two similar enamels with little more labour than to make one, using one of them as the trial plate for the other.

It is not until the learner has spoiled many plates that he will recognise how much disappointment and failure the trial plate will save him. Besides, if in the course of the work a new idea occurs of using some special enamel, of whose composition he is doubtful, he has ready a plate which has exactly gone through the same process as his enamel, and therefore is eminently fitted to test the proposed enamel.

Lastly, a log book should be kept of work and results. The trial plate should be ticketed, and notes made of the processes used in them. All failures should be carefully noted. The various enamels should be kept in separate drawers, and also labelled. In this way a most valuable collection of notes will be formed, and it will be possible to eliminate untrustworthy materials.

It is very tempting to use all sorts of enamels; but I would advise working as much as possible with five or six well-tried stock colours, getting variety by variation of thickness and arrangement and by superposition.

In this way, and with the aid of the notes, effects once got will always be capable of being repeated.

The merely mechanical part of the art takes some time to acquire, and some persons will, of course, learn much quicker than others; but even the mechanical part of the process takes some months of patient work.

It is most desirable to follow in order from simpler

work to that which is more elaborate. A diary should be kept recording successes, failures, and their causes.

The desire to astonish one's friends is so great that it constantly leads a student to hurry on to more showy work before he has mastered simpler. If he could only have the reticence and self-denial not to let any one see a single bit of it till he has become expert, it would be best. And if any one asks a beginner for a specimen of his art, let him follow Ruskin's advice, and send him a piece of copper with some bits of enamel, with a note saying that in this condition they will be more valuable than when he has smeared the one over the other.

Chapter IV

CLOISONNÉ ENAMELS, JEWELLERY, AND IMITATION GLASS GEMS

CLOISONNÉ enamel is usually employed for jewellery, and done with gold. Pure gold is known as "fine gold." Gold is alloyed with silver or copper; the amount of alloy is expressed by the number of parts of fine gold in 24. Thus 18 carat gold means gold to which a quarter of its weight of silver or copper has been added. Fine gold is very beautiful, but very soft. It is never employed now for jewellery. I would advise nothing else for enamelling, as it resists the fire admirably, and however heated does not blacken, whereas gold with even 1 per cent. of alloy tarnishes with the fire or with exposure to the air. When covered with enamel, fine gold becomes quite stiff enough for ordinary use. Gold may be cleaned by heating it and plunging it into nitric acid. It then takes a splendid yellow tone. It should be left a little time in the acid, then rinsed with plenty of clean water, and finally dried in hot box-wood sawdust. Jewellers are obliged, from motives of economy, to use alloyed gold for enamelling, but it sometimes melts or softens in the furnace, and its use

often leads to disappointment. When heated, all kinds of alloyed gold or silver come out black from the furnace, but pure gold and silver come out quite clean and unoxidized.

In the manufacture of jewellery the first essential operation is soldering. To solder two pieces of metal together, an alloy is made which melts more easily than either of them. It is a well-known but unexplained fact that alloys melt at a temperature less than the metals of which they are composed. Thus, if some common solder, composed of lead and tin, is heated to a temperature much less than that of copper, it will amalgamate with and melt into the copper. For this purpose, however, the copper must be perfectly clean. To clean it, mere scraping with sand or emery paper is not enough; for the heat would cause oxidation, and thus continually recoat it with oxide. We need, therefore, a solvent for the oxide which shall not be driven off at the soldering heat.

For soldering brass, copper, or tinned iron, a solder is used composed of lead and tin, called plumber's solder, and made hard, *i.e.*, one lead to two of tin; medium, and soft, *i.e.*, one lead to one of tin. The copper or brass is well cleaned, and then covered with a little resin, or else with liquid chloride of zinc, often mixed with sal-ammoniac. When heat is applied, the water in which the chloride of zinc and sal-ammoniac are dissolved is driven off, and the salts then fuse into a liquid state, in which condition they powerfully dissolve the oxides on the metals, and allow the solder to adhere.

But plumber's solder is weak, and would never do

for jewellery, because any trace of lead in or upon gold instantly permeates deep into the metal, and renders it brittle. We thus require a harder solder. This is to be found by mixing gold with silver, copper, or brass.

Here, however, we are presented with a fresh difficulty. The brass or silver is volatile, and at a great heat might be driven off. Again, the chloride of zinc and sal-ammoniac, that answered as fluxes at the low temperature of plumber's solder, must be replaced by some solvent which better resists heat.

The danger of volatilization of the more volatile parts of a solder is guarded against by heating the work well before the solder is put on, and a convenient flux is found in borax.

There is, however, yet another danger. If a small piece of gold is to be soldered to a large piece the small piece gets heated first, for its surface being large in proportion to its bulk, it absorbs heat rapidly. In consequence, the solder rushes off to the small piece and bathes it, leaving the larger piece dry.

Moreover, borax presents difficulties, for it contains a great quantity of water of crystallization, which causes it to bubble up when heated, and dislodge the work, and burst open joints in which it has been put. These difficulties may, however, be got over.

First, as regards the borax, if it is melted (so as to drive off the water) into a brittle glass, and then finally ground up to an impalpable paste with the petroleum which has been described for use with grisaille, it will give no trouble by bubbling. I believe this plan is new, and it is certainly effective.

In the next place, care should be taken to heat the

larger pieces first. Thus, if a very small bit has to be soldered on to a large thin surface, the heating should be done from the back of the bigger piece.

Again, if the joint to be made is large, it will perhaps be possible to heat the work up first, then, when it is red hot, to put the solder on, and suddenly reheating it to cause the solder to run before it has time to become volatilized.

If part of the work is very thin, and in danger of being melted, it is possible to protect it with a layer of fire-clay. For this purpose plaster of Paris mixed with four times its bulk of tripoli powder answers admirably, forming a paste, easy to scrape off, but perfectly unalterable by the fire.

The volatilization of the solder may also be greatly hindered by hammering it well before use, and using it in as large bits as possible. Only just enough solder should be employed to make the joint, for otherwise it runs over the gold and spoils its appearance. Besides, there is a danger of its becoming incorporated with the gold, and causing holes to be melted in the work. Hence, then, we have the following rules. Clean the work well; use borax, ground in petroleum. Do not put the solder on in too small pieces, but let them be as reasonably large as possible. Use as little solder as you possibly can. Avoid playing the flame, if you can, on the solder, but rather play it well on the bigger parts of the pieces which are to be soldered. If the work permits of it, heat it before you put the solder on, and cover up the more delicate parts by a paste of fire-clay or some preservative substance.

When solder is melted, if it is suitable for the work

in hand, it is very adhesive, running by capillary attraction over everything, and drawing joints together. If the softer metal in it becomes volatilized it will not run, but forms into little globules, and spoils the work.

A suitable solder for any sort of gold is the gold itself alloyed with one-sixth of its weight of silver. Fine gold can be conveniently soldered with 18 carat gold.

If the work is to be enamelled, the solder must not be too fusible, as it would melt in the heat. Any soldered parts of the work that are to be exposed to the heat of the furnace and are not enamelled must be protected with a covering of clay.

For copper or brass, a solder composed of 2 parts of silver and 1 part of the finest brass (got out of brass wire) is employed. Or, again, equal weights of copper and silver coin can be used. It is a little harder than the last. But it is not economical to make solder out of coin, for the metal in a shilling is only worth seven-pence. The zinc in the brass greatly assists the fusibility of the solder.

Gold is one of the most malleable metals known, and may be twisted, or hammered, or rubbed into any shape. But a very little working makes it hard, and it then needs annealing, that is to say heating to a dull red, and then allowing it to cool. It is best not to plunge it into water (a process which improves the annealing of copper). The gold must be repeatedly annealed. At first every two or three minutes is not too much.

As soon as the work has been hammered, and bent, and rubbed approximately into shape, finer work can be done by backing the gold upon a lump of melted pitch, and when it is cool, working upon it.

A few lessons upon this part of the art can be got at any technical school.

When finished, the article can be cleaned in warm dilute nitric acid, well washed, and then burnished. But fine gold must only be used for necklaces or lockets, or articles which will not be subjected to much hard wear.

For cloisonné work, both the foundation and cloisons should be made of fine gold. It is necessary to have a small draw plate made with a very fine rectangular hole.

Fine gold wire should be annealed and drawn through this hole. It will then become proper for cloisons. Of course thicker or wider wires might be used if desired. Very pretty cloisons are sometimes made by twisting together two wires into a rope, or with the crinkled wire used by makers of filigree work. This does not seem to be employed in England, but may be procured in Geneva.

This wire is then bent to the shape of the cloisons, placed in position, and the junction with the gold foundation slightly touched with a fine camel's-hair brush moistened in the borax and petroleum preparation. Little bits of fine wire solder (18 carats) are then put in so as to lie close to the cloisons, and a mouth blowpipe with a Bunsen or alcohol lamp will soon melt the solder; or, if possible, it is better to use a larger blowpipe, and heat the work from the back. It is better to put the cloisons on not too many at a time, because mistakes are thus more easily rectified.

It would be fatal, of course, to use plumber's solder for this purpose, as the lead would at once eat the gold into holes. In fact, if any lead gets into contact

with gold, it must by no means be heated (which would only alloy them the more), but must be at once dissolved away with warm nitric acid.

Nor, again, for enamelled work is it wise to use solder of less than 18 carats, for poorer solder is also apt in the furnace to eat the gold into holes.

As soon as the gold work has been completed, any roughness may be removed with a scraper or the file.

Beware, however, of attempting to get the piece too smooth. An affected rudeness of work is of course offensive, like the mannered slobbering of a certain school of modern painters. But, on the other hand, affected neatness takes all character out of the work, and makes it of the "tea-tray" order. It should be neither horribly bristling with rough edges, nor smoothed down like a piece of modern Birmingham jewellery. It is difficult to work with very thin gold. The best thickness is about ·02 inch.

As soon as the gold work has been completed and well pickled in nitric acid till it is of a splendid colour, the enamel may be laid on.

It must be very finely powdered, well washed, and laid on with a small spatula, or else a brush.

It may then be fired in a large alcohol flame or else in the muffle furnace. But it must not be put into a gas flame of any sort, as the sulphur would reduce the lead and blacken the enamel.

In the furnace the work must be propped up on all sides with small pieces of thin iron, painted over with whiting (or chalk, which is the same thing) and pipe-clay. Of course it should only rest on sharp points of iron, so as to leave as few marks as possible.

Instead of soldering the cloisons down, they might have been stuck down with celluloid in acetate of amyl, or with collodion, and then the melted enamel would keep them in place. But this plan is not a good one, because at each reheating they all become loose, and may shift their position.

Small sham jewels can easily be made by putting on little circles, lozenge shapes or ovals, of cloison, and then filling up brilliant transparent enamel on them, and fixing it so that it projects like a sort of drop. It then looks like an uncut stone. Such ornamentation is legitimate if it is not made to impose on the spectator, but real jewels are preferable. They are very easy to fix by bending strips of cloison to serve as cells, and soldering them on; and then, when all the enamelling has been done, the stone is slipped into its cell, and the edges of the cell burnished down over it with a small hardened steel burnisher. Little pearls are often hung from such work by means of gold wire.

The enamel may be loaded on till it projects above the cloisons, and then the surface ground over with an emery file and water, and finally polished, first with pumice powder and water, and then with rotten stone. But such work has rather a tame and smooth appearance.

Of course, if preferred, the enamel can be laid on over the jewellery without any cloisons. Most effective work can be done in this way. Fine gold, when covered with flux, takes a colour so vivid as to be almost too powerful. Its splendour must be seen to be appreciated, and it generally needs toning to be endurable.

Silver work is similarly executed, except that the pickle for silver should be dilute hydrochloric acid, and as it is soft, great care is needed in firing. But with blue and green colours, enamelled silver gives splendid effects. Reds and yellows do not harmonize so well with it.

Parti-coloured work is also effective, especially in making small coats of arms for lockets, but it must be used with discretion in order not to look vulgar.

In fact, as a general rule in making jewellery, the necessity of restraint cannot too often be insisted on. A mass of tiny brilliants is a beautiful thing, whereas the Koh-i-nûr is like an ugly lump of glass.

By grinding up old broken china with half an equal weight of flux, a clay can be made which, in the fire, will set like porcelain, and can be afterwards enamelled, and then painted.

The royal blue beads found on mummies can be easily imitated in this way. The blue enamel must be roughly laid on, and is made out of cobalt glass with a very slight admixture of green copper glass. The markings on it are then made with flux, oxide of iridium and cobalt. White enamel for the same purpose can be made out of the ordinary flux and tin. Most curious necklaces can thus be made.

If care is taken in the annealing, ordinary china or porcelain can be beautifully ornamented with enamel and gold. The soft enamels used on metal are admirable for this purpose. They may be ground with water or petroleum and laid on.

A good plan for making gold enamelled book-covers, or indeed any form of ornament, is first to model a design in modelling wax, then take a plaster cast of

that, and then a cast of that again in ordinary pewter, to which a little antimony has been added to harden it. Or better still, take an electrotype of it, well backed with hard solder. Then take a sheet of fine gold, of from about $1\frac{1}{2}$ grammes (one pennyweight) to the square inch on it, and, with repeated annealing, burnish it well on to the metal mould, which should previously be wiped over with grease and blacklead to prevent the gold from sticking; then melt it on to pitch, and finish it up with a pointed burnisher. This, if enamelled in transparent enamels, will have a brilliant effect. The only fault will probably be that it will be too brilliant, but that fault can easily be corrected by toning it with darker enamels ground in petroleum as described elsewhere. Silver may be similarly treated, but should be rather thicker. Beware also of silver soldered joints; they are very apt to eat into holes when enamelled. The different parts can, after being enamelled, be easily stuck together by means of enamel, which forms an excellent solder for them.

In all the above work I strongly advise the use of nothing but fine gold, or at all events gold over 20 carats. I also recommend the amateur not to try and imitate modern work, but to go to the British Museum and study old Greek, Assyrian, Egyptian and Celtic jewellery, and then design something in those styles; or better still, with the inspiration derived from the contemplation of these, try and design something modern. The work will look splendid if fine gold is used, well pickled in nitric acid. Some little care must, however, be taken not to expose the enamel to too strong acid, as there are some colours,

notably browns, which it will decompose. If it is wished to remove enamel, you have only to heat the object to a low red, and plunge it in cold water. If this is done several times the enamel will crack off.

Fine gold may be burnished with an agate burnisher and cleaned with a little alcohol, putty powder, and a soft brush. Enamel may be filed into shape with an emery stick. If it is then washed over with hydrofluoric acid and fired, it will again become quite brilliant, or it can be polished with fine emery, followed by rotten stone, and last of all, rouge.

For very dirty jewellery make up a paste with soap, and 5 per cent. of rouge for hard metals, or putty powder for soft. This soap, used with a brush and warm water, will clean things excellently, and, curious to say, rouge-soap cleans the hands in a most extraordinary manner. But dirty hands are best cleaned by a good rubbing with vaseline, and then washing with soap and water.

It is unfortunate, as has been already remarked, that electrotypes cannot be enamelled owing to the occluded air they contain. It is, however, possible to employ them indirectly. Thus, if a jewellery design be executed in modelling wax on a piece of glass, it may be well rubbed over with a little plumbago, or better still, with the special bronze powder sold for that purpose. The best copper-coloured bronzing powder answers well. It may then be electrotyped, by arranging a bath with a half-saturated solution of nitrate of copper, to which about a thousandth part of sulphuric acid is added. The current should be about one-fifth of an ampère to the square inch. In two or three hours the electrotype will be finished. It should

then be "backed," by rubbing the back over with a little chloride of zinc, and then filling it in solid with melted solder. A piece of pure sheet gold weighing about a gramme (*i.e.* 15½ grains) to the square inch (that is to say, about twice the thickness used for paillons for Limoges enamelling) may now be squeezed and burnished over it, and hammered into the hollows with little plugs of soft wood. The gold should be *repeatedly* annealed, and if the burnishing is well done, an exact copy can be taken of the electrotype, with every scratch sharply marked. Most beautiful impressions of medals may thus be made. All that is wanted is patience, and plenty of annealing.

These may then be enamelled, back and front, with transparent enamels. Little heads, ships, and other objects can be made by modelling them in wax, then making a mould in plaster of Paris, and then a cast in fusible metal, composed of lead, tin, and bismuth, say equal parts of each. This should be well brushed over with plumbago. The gold can then be burnished on to the cast, and worked with stamping and embossing tools, and then enamelled both inside and out. If any lead sticks to the gold it must be at once dissolved off with nitric acid. This is a good way to make handles to cups or jewellery of all sorts. The gold is plastic to an extraordinary degree, and if only repeatedly annealed can be moulded and stretched like wax.

Electrotypes can be taken straight from copper medals if care is taken to coat them well with plumbago and alcohol, and then when the coating is dry to brush off the plumbago with a soft brush. An exceedingly thin film of plumbago is always left, which

prevents the type from sticking. Of course, valuable medals must not be treated in this way. The electrotypes thus obtained can be used to obtain gold "squeezes," which in their turn can be enamelled.

Imitation intaglios can also be produced, for in this case all that is needful is to make a gold mould, by burnishing down the gold upon a medal or other object to be copied. Turn it upside down, and then enamel it over with a coating of enamel, laid on in the usual way. Then some large bits of enamel as big as beans should be piled on and allowed to melt till you have filled up the whole of the gold mould. It must be well annealed in hot sand or ashes. The gold cannot be picked off, but must be dissolved away by hot aqua regia, one part of nitric acid to four parts of hydrochloric, and you will have a very fair copy of the original medal in enamel, which will look like an antique gem. The dissolved gold can of course be used to colour enamel with. With care, the imitation gems can be made parti-coloured. By using flux with 10 % of arsenic in it opal intaglios can be imitated.

But a better method of making artificial gems is to squeeze glass into a properly prepared mould of some material which will not stick to the glass. This condition excludes the use of clays of all sorts, or of any material containing alkalis or metallic salts. In 1712 the chemist Homberg proposed a method of imitating gems with tripoli moulds which is said to have been practised with success, but which only seems to succeed with small pieces. After some experiments I have succeeded very well by the following method, founded in part on that of Homberg.

Take fine tripoli of Venice. (This is composed of silica, with about 6 per cent. of clay, and coloured with a little iron.) Mix it with one-fifth of its bulk of the finest plaster of Paris, and having made them into a paste with water, cover the mould (which has been previously greased with suet) with a layer about one-eighth of an inch thick. Then fill in with common plaster of Paris. The commoner kind must be used for the filling, because the finer sorts of plaster, when unmixed with tripoli, will not stand furnace heat. You thus have a strong plaster cast, faced with fine plaster and tripoli, but with the body composed of common plaster. When it has well dried, put upon it a piece of glass, and put all into the muffle furnace. As soon as the glass begins to melt, the cast should be taken out of the furnace, and the glass pressed into it with a painter's putty knife. It should then be put back, and when it has become hot it may be pressed again, and if needful, more glass added. After four or five pressings it ought to be finished, and may then be put into a mass of hot ashes to cool, for three or four hours. The plaster and tripoli will come off on soaking in water. The glass should then be cleaned (carefully) with hydrofluoric acid. It is best to use a dense flint glass, because this looks more brilliant, and is less likely to crack with imperfect annealing. Where hardness is wanted, a soft soda or potash glass must be used, but it must be most carefully annealed. The edges can be shaped on an emery wheel, or on a brass disc fed with wet emery powder, and finished up with emery powder upon copper laps such as lapidaries use.

It may finally be polished with a soft circular brush,

rotating in a lathe, and fed with putty powder and water. The cutting and polishing can easily be done by any lapidary. Variegated pieces of glass cleverly arranged can be got to imitate agate. Ordinary soft enamel is very suitable, and can be tinted by mixing the enamels used for Limoges work with about six to twenty times the quantity of white glass. A trace of violet manganese glass gives a violet like amethysts, a little copper with a trace of iron imitates an aquamarine.

In this way medallions may be modelled in wax on pieces of flat glass, and then easily reproduced in glass, but the greatest care must be taken in long and thorough annealing.

By plique-à-jour we mean filigree-work executed in gold or silver, and filled up with transparent enamels. It existed in the time of Benvenuto Cellini.

It is done by first preparing the filigree. If silver is employed, it must be pure, and soldered with low-standard gold solder. The holes must not be more than about $\frac{1}{4}$-inch diameter. The enamel is laid on with pure water, the filigree being vertical. It is dried and rapidly but gently introduced into a *very hot* oven. The enamel used must be soft, and the initial heat very great, or else the enamel will not spread like a soap bubble over the space.

Champlevé is difficult and requires considerable hand-skill. Electro-gilding is essential for the artist in champlevé. The art of gilding is very difficult, but may be learned from several excellent text-books.

The enameller, however, does not want to learn the difficult process of gilding with alloyed gold, and, fortunately, to gild with pure gold is exceedingly easy.

Such gilding as this is very soft, and not suitable for the hard wear of personal jewellery. If, however, all that is wanted is to gild miniature frames, enamels, clocks, and other objects which will not be submitted to rubbing, then gilding with absolutely pure gold is preferable; for gold with the least alloy will tarnish, whereas articles gilded with pure gold will never lose their colour.

Procure a piece of absolutely pure sheet gold weighing about 2 oz., and hence worth about £9.

Take a bain-marie, or one of those china pots called "gourmet" cooking pots, of 1 gallon capacity. Nearly fill it with distilled water, to which add 1 lb. of cyanide of potassium. You must not use the common cyanide, but a pure kind specially prepared for gilders. Put the gourmet pot into a large saucepan or kettle of water, and keep it at about 140° Fahr. with a Bunsen gas burner. If you have constant current electric light in the house, pass the current through a 2- or a 5-candle lamp, and then put the ends of the wires one on to each piece of gold; one of them will at once begin to give off hydrogen gas. This is the negative pole. Put it inside a perfectly clean porous cell to keep the gold from depositing on it. Fill the cell with cyanide solution, and put it into the gold bath. The gold will then be dissolved from the positive pole, and since the porous pot prevents it getting on to the negative pole, it will diffuse into the solution. As soon as the solution has taken up ½ oz. of gold, the contents of the porous pot can be added to the bath and the porous pot removed, the piece of gold on the negative pole added to that on the positive pole called the "anode," and the bath is ready.

The article to be gilded must be completely cleaned, then well scoured with powdered pumice stone, then boiled in hot cyanide of potassium for a few minutes, and then scoured again with powdered pumice stone and water, finally well rinsed with clean water, and then put on the negative pole into the solution at a temperature of 140° Fahr. and gently moved about. In about three minutes a reddish-brown coating of gold will have formed on it. This may then be washed, burnished with a scratch brush of fine brass wire, either on a lathe or worked by hand, and moistened with a little beer, or vinegar and water. It will take a splendid burnish. It should then be washed, and dried in sawdust, heated in a vessel with a water jacket. If you have not got electricity in the house, then a 2-cell Daniell's battery must be employed, but after each use it must be taken to pieces and washed and the parts put away, or else the porous pots will be destroyed and the zincs also. The anode must be at least as large as the piece to be gilded or else the gold will not deposit uniformly.

The advantage of the above method is that it does not seem to matter much how strong the current is, or how hot the solution is, or how strong the bath is. It succeeds almost any way, whereas the usual method of gilding is very delicate. The practised gilder who uses alloyed anodes can give any shade of colour he likes to the work. The above method can give the colour of pure gold only, but I think that colour is far more beautiful than any alloy. The old method of gilding was by means of mercury-amalgam. This method is very beautiful, but most dangerous, and those who practise it are liable not only to sali-

vation, but even to necrosis of the jaw. (The same effect is produced by phosphorus, and known as "phossy jaw.") It is still a little practised.

We little think, when we see the beautiful old gilded work, what terrible illness it caused to the workmen, and just as little are we apt to reflect, when we see houses painted with white paint, or lead-glazed crockery, on the mortality they involve. But the days are rapidly approaching when these trade-illnesses will be swept away for ever by the adoption of safer processes. It is now only a question of the time necessary to discover and apply them.

Very handsome frames may be made for enamels out of hammered iron plate.

German silver, also, gives a fine effect. Both these are, however, liable to tarnish, and cannot be heated in a muffle.

There is, also, a compound of nickel called kronand-metal, which works fairly well.

But for beauty of colour nothing comes up, I think, to pure nickel, which can, like iron, be obtained in sheets. It is capable of being soldered with hard solder, and a frame of nickel covered with ornamentation of burnished gold is very beautiful. The fire only gives it a sort of dull patina, which is very fine, and by the use of acids can be made almost any colour you like. If on the nickel you paint figures with gold powder mixed with gum water and a little borax, and fire them well in the furnace, and put on more gold and fire again once or twice, and then burnish the gold with a hematite burnisher, a very beautiful effect is obtained, like the Indian gold-inlaid work. The gold adheres well, and is

difficult to get off except with a scraper. Nickel is capable of producing all the effects of silver, and in addition does not tarnish. But it will not take enamel, for it gives rise to bubbles and the work comes off.

For work on thin metal as described, it is always necessary to have a counter enamel, otherwise the coating may split off. But when the metal is thick, say $\frac{1}{20}$th of an inch or over, no counter enamel is needed. In that case the enamel will hold. But unless there are cloisons, or deep incisions, or the work is well roughed or carved, there is always a danger of the enamel splitting off. The enamel is very apt to fly off small solid figures. For such work the best to use is a soft enamel, in spite of the fact that it is not well adapted for hard abrasive wear.

But the most durable work should be done on thin, fine gold well counter-enamelled, and set if need be in a solid setting.

The diamond is almost the only stone that will stand the fire, so that a setting of diamonds may be enamelled right among the diamonds, and all put together into the enamelling furnace. I have, however, met few persons courageous enough to try this apparently risky operation, and diamonds are usually inserted, like other precious stones, after the enamelling is finished.

Silver and copper and brass are improved in appearance by the formation upon them of a film or patina.

The Japanese are the greatest artists at this work, though their productions are often more fantastic and curious than beautiful.

The blackening of silver, or "oxidation," as it is usually termed, is done in many ways. One of the most common is to produce upon it a thin film of dark sulphide. This is effected by making a solution of a gramme of sulphide of potassium in 100 cubic centimetres of water (or 1½ drachms to a pint). It is applied with a brush on the heated metal, and may be then scratch-brushed or burnished.

A scratch-brush is, as before described, a brush with fine brass wire bristles, used with vinegar or weak beer.

A paste (made up with water) of rouge and black-lead may be laid on copper and heated till the whole becomes black, then cool and brush with beeswax and a little of the paste dried.

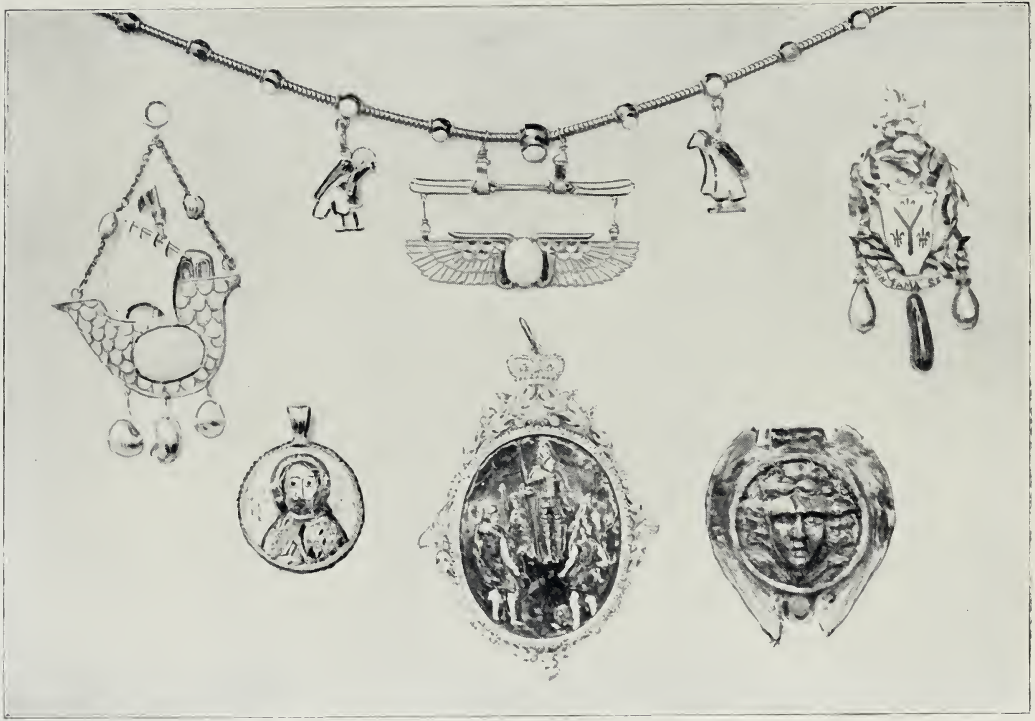
It is also worth knowing that a sharp impression of a seal, very suitable for electrotyping, can be got by putting a sealing-wax impression on an anvil, covering it with one or two pieces of soft sheet-lead, and then hitting it a severe blow with a very heavy hammer. Pressure would cause the wax to pulverize, but a quick, heavy blow drives the wax into the lead, producing a sharp impression.

The woodcut upon the opposite page represents a few ornaments designed and made by the author.

No. 1 is a cloisonné design based on the ornament usually placed on the breast of mummies. The sun (represented by an opal) is provided with wings. The upper part represents the feathers of truth, and the whole is emblematic of a future life.

No. 2 is an armorial shield on gold. The slashed mantle is tinted, of appropriate colours. The helmet is left bright gold.

No. 3 is a repoussé plaque of gold representing an historic episode, and enamelled over with subdued colours. Its setting is antique.



4 1 2

5 3 6

No. 4. A ship in cloisonné. A large opal is set in the centre, and three pearls hang from it. The colours are opaque, turquoise, and cobalt blue.

No. 5. Head of Christ in cloisonné, in the Byzantine manner of working, on a flat plate of gold.

No. 6. A Medusa head, repoussé in gold. The colours are blue, green, and a reddish bronze on the face (transparent enamels).

Chapter V

THE MANUFACTURE OF ENAMEL

ENAMEL consists of glass. Glass is composed of silicates of various materials. In nature it therefore somewhat resembles a salt, that is to say, the union of an acid with a base; but it contains no water of crystallization, nor is it in a crystalline form. It is amorphous, that is to say, like a mass of solid varnish or glue; it possesses no definite structure. There are two acids which enter into the composition of glass, namely, silica (the oxide of silicon) and boracic acid (the oxide of boron), but the latter, as we shall presently see, is not a desirable ingredient. The bases which are mixed with the above-mentioned acids to form glass are, in the first place, soda and potash, being the oxides of the metals sodium and potassium. In addition to these, oxide of lead is an essential component of glasses used for enamelling, on account of the peculiar elasticity and other qualities which it produces, but we may also have as a base alumina, chalk, or magnesia. These last, though much used as bases in the composition of window glass or of the glasses used in glazing china and pottery, are of no particular value in the composition

of enamels—indeed, they are apt to alter the shade of some of the colouring matters employed, and to produce complications in the character of enamel, which, for facility of manufacture, it is desirable to keep as uniform and simple as possible. Instead of lead, bismuth might be employed, but it possesses no advantage over lead, and its great cost renders its use undesirable. For certain kinds of optical glass, baryta (the oxide of barium) is used; it is found to give whiteness and uniformity, but produces no quality in the glass which improves it for use as an enamel.

Silica (SiO_2) occurs in nature in the form of sand, flint, agate, or quartz. As found in nature, it is crystalline. When pure, it is of a dazzling white. Its coloration usually proceeds from a small admixture of iron. When pure, it cannot be melted except with the oxyhydrogen blowpipe, upon which it loses its crystalline structure and becomes amorphous, and may be drawn out into threads, and, if it could be subjected to sufficient heat, might be worked like glass. If this could be done, we should be in possession of a magnificent material, a perfect non-conductor of electricity, absolutely unchangeable by atmospheric influences, indissoluble by almost all chemical substances, of a hardness approaching that of the diamond, and perfectly translucent; but the power of working at the tremendous temperatures necessary to make pure quartz ware belongs not to the present, but to the future. But when silica is heated with any metallic oxide such as soda, potash, alumina (clay), magnesia, baryta, oxide of lead, oxide of iron, etc., it fuses into a glass, or slag. This fact forms the foundation of all glass, earthenware, pottery,

tile, and brick-making. In conjunction with potash or soda, silica is capable of forming two distinct orders of compounds—one, an insoluble silicate known as ordinary glass; the other, of the kind known as the soluble silicates of soda, or potash, commonly called water-glass. These curious soluble silicates are produced by strongly heating powdered silica with four or five times its weight of soda or potash, and then boiling the result with water. They may be obtained from any druggist in a form resembling thick mucilage, which may be thinned down with any amount of water, and in this more liquid form are employed mixed with fireclay for mending furnaces, or with lime and other materials for producing artificial stone and indelible whitewash. Water-glass has this curious property, that, if in the liquid form it is mixed with a powerful acid, such as hydrochloric acid, it is decomposed, the hydrochloric acid entering into composition with the soda or potash, forming chloride of sodium (common salt) or chloride of potassium. The silica thus isolated remains either dissolved in the water or else in the form of a cloudy, gelatinous mass, which, when dried, becomes a light, fine powder of dazzling whiteness. In this state it is insoluble, so that dissolved silica, when dry, becomes insoluble, and can only be rendered soluble again by the artifice of making it into water-glass with alkali, and then removing the alkali with hydrochloric acid. But water-glass would be quite unfit for the manufacture of enamels, or for making windows or bottles. For these, an insoluble silicate is needed, and this may be obtained by simply reducing the quantity of soda or potash. If we melt together three parts of silica

to one of soda or potash, the mixture requires far greater heat to fuse it, but instead, as in the case of water-glass, of becoming an opaque white mass soluble in water, it now takes the white transparent form which is so well known. Another very curious property of silica is, that its acid properties are only fully developed by heat. At low temperatures it is a weak acid, so that silicate of soda is decomposed by hydrochloric acid. But at a red heat it becomes the most powerful acid known, dissolving everything, and displacing all other acids. The glass-maker usually employs sea sand for his quartz, but owing to the iron with which almost all sand is contaminated, the resulting glass becomes of a dirty yellow or bottle green; for the finer sorts of glass, therefore, a pure white sand from Fontainebleau Forest or Pegwell Bay is much in request. Silica is also sometimes got by calcining common flints and then plunging them into cold water so as to crack them up. They are then ground with water in granite mills; but this is an expensive process, only employed for certain glazes used in china-making. The soda and potash obtainable by the glass-maker have not, till recent years, been free from iron, and hence old glasses were always apt to be slightly tinged with colour. Better alkalis are now in general use, but in old days it used to be customary to neutralize the tint produced by the iron by the addition of a small quantity of manganese. Silica is capable of uniting not only with alkali, but also with lead, lime, magnesia, and clay (hydrous silicate of alumina). In conjunction with these it forms glasses of different sorts, but if the amounts of lime, magnesia, and clay are large, the mixture does not

become transparent, and, in fact, is only partly vitrified. In this condition it is "porcelain." Crockery consists of clays, lime and magnesia, containing only very small proportions of silica; and earthenware consists wholly of these earths or clays, with no silica to speak of other than that in chemical combination in clay. Thus, then, glass, porcelain, crockery, earthenware, bricks are all a kindred family; consisting of silicate of soda or potash, or lime, alumina, and magnesia, and varying from the finest crystal down to the most ignoble slag. There is no sharp dividing line. Glass glides into semi-transparent porcelain, this again into china, china into crockery, crockery into earthenware, earthenware into terra-cotta, terra-cotta into brick. And all the family may be glazed over with glasses of various descriptions. In fact, any substance, clay or metal, may be glazed over with glass like a coat of varnish if only it will stand the heat necessary to melt the glass; but the "body" must be adapted to the glaze, or else the glaze will crack, or, as it is technically termed, "craze." The glazes on china, bricks, tiles, and enamelled pots are only so many varnishes made of various preparations of silica.

The alkalis.—The word alkali, derived from the Arabic, is used for the oxides of sodium and potassium, which are obtained from wood and various plants. If wood ashes are boiled in water, the water extracts from the ash a matter of a soapy taste, most valuable as a cleansing agent, and which, when mixed with any form of grease, forms what is known as soft soap; hence greasy plates boiled with wood ashes would become perfectly clean. In former days washerwomen used to clean clothes with the ashes from their

wood fires, and this is still done in France. Soda used once to be confused with potash, for the distinction between the two substances was unknown. Certain plants of the order known as frog-grass, and which are found in Egypt and other parts of the world, are rich in soda. Soda, combined with grease, forms hard soap. Both soda and potash are used by the glass and enamel-maker. Potash is best when it is desired to obtain whiteness and brilliancy, but when a glass is required which shall be easily fusible, elastic, and which shall possess the valuable property of remaining ductile for some time after it is heated red-hot, or, in other words, of being malleable at a red heat, soda is employed. Alkalis have the property of rendering glass more readily fusible. This effect also is produced by lead. But where the enamel is required to be easily fusible but yet hard, alkali is preferable to lead. On the other hand, however, glass rendered fusible by considerable quantities of alkali is more likely to crack if imperfectly annealed, and has a less brilliant surface. Soda is much cheaper than potash, a fact which becomes very apparent when we reflect that the salt of the sea is almost wholly composed of chloride of sodium. Our forefathers did not know how to extract the soda from chloride of sodium, and hence were unable to adopt what may appear the simple plan of making their glass out of sea salt, but modern science by means of electrical processes is able to do this with ease, and soda is now becoming cheaper than ever. It would be of no use trying to make glass by fusing together silica and sea salt (chloride of sodium), for the chlorine holds the soda too fast to allow the silica to get it at any

practicable temperatures. For glass-making we must employ some form of soda salt, the acid of which is of a less tenacious character, and therefore the sulphate, the nitrate, or the carbonate should be used; and the same is true of potash. Considerations of economy cause the use of a good deal of sulphate of soda, but the sulphur from the sulphate is apt to discolour the glass. Nitrates of potash and soda are very excellent, but are expensive, as the nitric acid used in their manufacture is costly. For the finer sorts of enamel, a soda is specially made, quite free from iron, called enamel-maker's soda. Hence the best materials for the enamel-maker to employ are the carbonates of soda and potash. When these are heated with silica to a bright red, the acid character of the silica, which manifests itself so little at lower temperatures, is brought into play, and, being more powerful than carbonic acid, it drives this out of the carbonate of soda; therefore the effect of the heat upon the mixture is to make it froth up, and first, to drive out in the form of steam the very large quantity of water of crystallization which carbonate of soda possesses, and next, as the glass forms, to expel the carbonic acid, which bubbles up through the melted glass as it does in soda water. The water of crystallization in the ordinary carbonates of soda and potash is uncertain in amount, varying with different specimens, and amounting sometimes to half their weight; it is therefore usual, before employing them, to calcine them thoroughly and then to keep them in dry bottles so as to prevent them absorbing more water. In all the formulæ about to be given it will be assumed that perfectly dry calcined carbonates are

employed, which can be purchased ready prepared from manufacturers of chemicals. There is, however, an important use to which the nitrates of potash and soda can be put and which renders them indispensable; it is due to their great oxygenating power. In the operations that will be presently described, there is a danger lest the carbon derived from the carbonate of soda may reduce the other ingredients to a metallic state. Oxide of lead is especially liable to this reduction, which causes the mass of enamel to become of a dirty black colour. Throughout the whole operation of melting enamels it is therefore necessary to keep the mass of melted matter well oxidized, and for this purpose no ingredient is so valuable as nitrate of potash. The large amount of oxygen that this substance contains, coupled with the ease with which it yields it up, is the reason why when mechanically mixed with carbon it forms gunpowder. If about 2 per cent. of it is mixed into the ingredients for making glass, reduction of the metals will be properly guarded against.

Lime (Ca.).—The addition of chalk (carbonate of lime) to silicate of soda constitutes with other ingredients the glass used for bottles and windows; the chalk increases the fusibility and the brightness and hardness of the material, but is of no service for enamels. On the contrary, it is rather prejudicial, as it makes them less flexible and less ductile when hot. It is, however, frequently found in small quantities in purchased enamels; its presence is an indication that window or bottle glass has been used in their composition. It is no bad plan to make enamels out of broken window glass, for repeated re-melting greatly improves the

quality; indeed, as will subsequently be shown, good enamel must be repeatedly fused and kept constantly in a state of fusion, and for this reason the enamel-maker should never employ crude materials, but should procure ready-made glass of good quality and known composition, and, having reduced it to a fine powder, should make his enamel by melting it up with other proper ingredients.

Lead (Pb.) enters into the composition of enamel in the form of oxide, and unites with the silica to make a silicate of lead. The glass, therefore, becomes an alloy of silicate of lead and silicate of soda or potash. It is sometimes recommended that the proportions of silica, oxide of lead, and alkali in glass should bear some definite ratio to the chemical equivalents of those materials, with a view of making the resulting glass rather into a chemical combination than a mere alloy; but it has been pointed out that mixtures or alloys of metal and other substances may be made without any regard to combining proportions, and indeed that the adoption of these proportions might rather have the effect of making the glass crystalline, that is to say, of its becoming devitrified, than of assuming that perfectly amorphous condition which is so valuable. The effect of the introduction of oxide of lead into glass is to make it softer, that is to say, more easy to scratch, more elastic, more malleable, and enormously to increase its refractive power; at the same time its melting-point is reduced to a degree considerably below the melting-point of copper. It is also much less likely to crack even when the annealing is imperfect. These qualities are those which make it possible to cover copper with a layer of melted glass without

melting away the copper which serves as a foundation. Glass containing one-third of its weight of oxide of lead is known as flint glass, and is used for telescope glasses on account of its high refractive power, and for cut table glass on account of its brilliancy. On the continent it is termed crystal. It was known to the ancients. Its specific gravity is about 3, or 3·2. Larger quantities than this of lead can be introduced into glass. When the amount of oxide of lead is about one-half the weight of the glass, it is termed dense flint, and has a specific gravity of about 3·6. Even larger quantities still of lead can be added, so as to raise the specific gravity up to 5, and enormously to increase the refractive power; but flint glass so dense as this is very difficult to make because the lead is apt to separate and cause devitrification. All flint glass has a faint yellowish tinge, and when the amount of oxide of lead reaches 60 per cent. the tinge is very perceptible. Very dense flint is used for the imitation of precious stones such as the diamond, and many secrets exist for making it of a white colour, but artificial diamonds are easily detected, for not only are they soft, but they are also opaque to the Röntgen rays, whereas the diamond is almost perfectly transparent to them. Lead is introduced into glass either in the form of the yellow oxide commonly known as litharge, or else in the form of red-lead. There is, however, a danger that it may be reduced to a metallic state during the melting. A very slight quantity of free carbon present in the mixture would effect this, for a quantity of carbon can reduce to a metallic state more than thirty times its weight of lead. Therefore, in making flint glass, care must always be taken to

introduce some oxidizing agent, and for this purpose a portion of the alkali is usually supplied in the shape of nitrate of potash. English flint is usually made with potash instead of with soda, because flint soda glass has a more yellowish tinge than flint potash, but in France crystal is frequently made with soda. Enamel consists simply of flint glass more or less dense. The harder kind of enamel used upon watches and jewellery that has to withstand wear is made of ordinary flint glass, containing 30 or even only 20 per cent. of oxide of lead; but such enamel is not very fusible, and has to be employed with care, lest in the application of it the metal which serves as its foundation should melt. It is sometimes made more fusible by large additions of soda or potash, but this makes it more easily affected by moisture, as does also the introduction of borax, which is very strongly to be deprecated. For enamels in the Limoges style which are to be looked at but not rubbed, or for enamelled ornaments which are not to withstand wear, nothing is better than a rather dense flint containing, say, 45 per cent. of oxide of lead; this is white, has a brilliant surface, and melts easily, so that there is little danger of the metal on which it is applied becoming drawn out of shape in the muffle furnace. Dense flint has, however, a disadvantage in this, that being so rich in lead, a very little carbon, such as a speck of dust upon the surface before it is put into the furnace, will cause the formation of a speck of metallic lead, which has to be cut out and filled up. With care, there is no difficulty in preventing the presence of the dust, and consequently such soft enamel is very suitable, for it melts at a low temperature, and thus there is no

danger of the copper plate being distorted, and the large amount of lead gives great brilliancy. It is difficult to procure fragments of real old enamel for analysis on account of their great value. I am inclined to think, however, that the quantity of lead used in them was not more than 20 per cent., but in many cases they seemed to have been rendered fusible by the use of borax, for I have noticed several old enamels which, in damp weather, were covered with beads of moisture, due to the hygrometric qualities of this pernicious ingredient.

Borax ($NaO2BO_3 + 10Aq$) is a borate of soda. Boron is an element having properties that render it analogous to silicon. The corresponding acid to silica is boracic acid ($HOBO_3$).

From this it might be inferred that just as silica (*i.e.*, silicic acid) forms silicates with all sorts of metallic oxides, so boracic acid would form borates. And this is the case. These borates are as a rule fusible, and exceedingly hard, that is to say, they will generally scratch glass. Boracic acid also unites easily with metallic oxides, and hence takes colour well, and also causes the glass to become very liquid and flow easily. It is therefore often used to make easily fusible enamels. But it has two defects. In the first place, enamels made with it are liable to crack, and are deficient in elasticity; and in the next place, they are very susceptible to moisture. Faraday, in search of a highly refractive glass, found that he could unite enormous quantities of lead in borax glass, but the product speedily tarnished. Otherwise it would have made a splendid optical glass for certain purposes.

More church windows have suffered from the rain through the use of borax than from any other cause, and there is no need to employ it, as perfectly good enamel can be made without it. In fact, its only use is to combine fusibility with a hard surface, and as there is no need for making Limoges enamel with a very hard surface, the necessary fusibility can be better obtained by means of lead.

Alumina, or clay, occasionally enters into the composition of glasses, but is of no use in the fabrication of enamels except in the formation of some greens, which, however, can be very well made without it.

The above-mentioned materials form a colourless glass called "fondant" in French, or "flux" in English.

Colouring matters.—The colouring of enamels is effected by the addition of small quantities of various metallic oxides, which, being dissolved by the silica, to which they act as bases, form silicates.

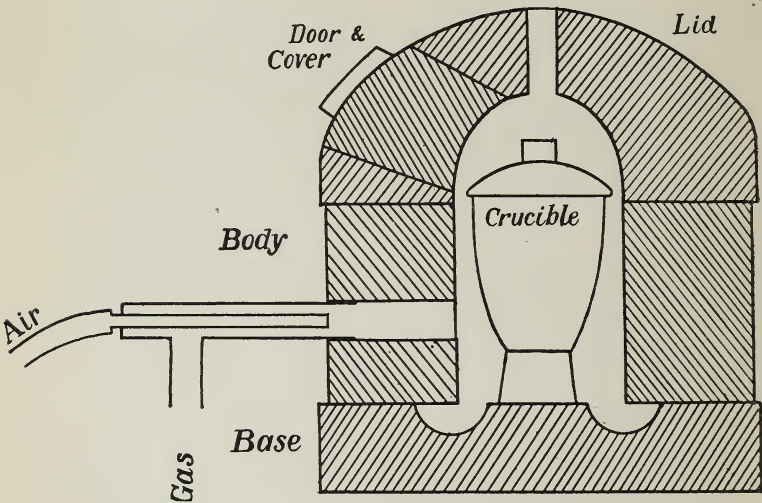
The principal metals so used are: copper, antimony, gold, chromium, iron, nickel, cobalt, manganese, platinum, iridium, and uranium. It is easy to test these colours by making a small bead of borax in a loop of platinum wire and heating it in the blow-pipe flame. The higher oxides of the metals formed in the outer flame at its extreme end as a rule give the best results. Red is obtained from gold; yellow from uranium and antimony; blue from cobalt; violet from manganese; green from various mixtures of iron, chromium, copper, zinc, and cobalt. A great variety of greens is obtainable. Black is produced by a mixture of cobalt, manganese, and iron; brown from iron and manganese, and also from nickel. Opaque white is

obtained by mixing the flux with oxide of tin, white arsenic, or phosphate of lime. A splendid black and most delicate shades of grey are produced from iridium, but it is a very expensive material. A soft, dove-coloured grey can be got from platinum. All the above ingredients can be mixed together to produce various shades of colour, but the brilliancy of the colouring is greatly reduced in mixtures, and besides, very unexpected results occur. One would think that cobalt blue, combined with uranium glass, the colour of barley sugar, would produce a green; on the contrary, it forms a fine indigo. Yellowish-green iron mixed with violet manganese produces red. Nothing but experiment can determine the colours resulting from mixtures, of which more will be said by-and-by. The shade of these colours depends generally upon the state of oxidation of the metallic oxide. Thus, manganese, if well oxidized, gives a purple colour; if less oxidized, it is reddish. Cobalt also becomes more red if well oxidized. Iron becomes more yellow if oxidized. Selenium when oxidized gives a full yellow, but if less oxidized, it gives a rose colour.

I now proceed to describe the method of practically making enamels. First we must make a flux. This may be either a hard flux, containing about 30 per cent. of oxide of lead, or a soft one, containing about 45 per cent. of oxide of lead.

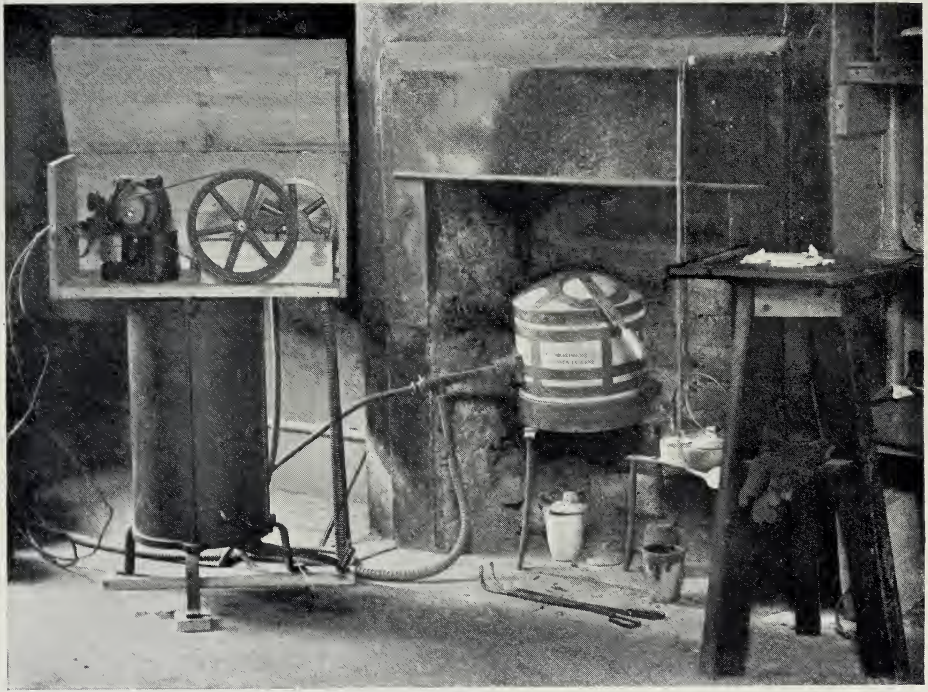
I will first describe the furnace. For ordinary work it is advantageous to have a somewhat small furnace, capable of holding about 1½ lb. of melted enamel. It should consist of a cylinder of fireclay, open at top and bottom, and should be 7 inches high, 5½ inches internal diameter, and with walls 3¼ inches

thick. The bottom should consist of a large slab of fireclay with a trench in it, so that any melted glass that falls down the sides of the crucible may flow into it and not stick the bottom on to the furnace. It will easily hold a Morgan's crucible, $4\frac{1}{2}$ inches high and $3\frac{1}{2}$ inches diameter across the mouth. The crucible should stand on a base 2 inches high, put on



Section of the Melting Furnace.

the bottom. By having the bottom separate from the body the furnace is kept from being clogged up, and is more easily repaired; for enamel-making is very apt to make a mess, and the enamel runs on the fireclay, and sticks to it so hard that it can only be got off with a chisel and mallet. The lid of the furnace should have a hole in it, so that the lid of the crucible



Gas Furnace, with an Air Blower driven by Electricity.

may be removed to stir it and inspect the contents without removing the lid of the furnace. The great thickness of the furnace is to make it retain heat. If a thinner one be used, it should be enclosed in a large cylindrical pot of sheet iron, and packed well with some non-conducting substance, such as fossil meal (Kiesselguhr) or asbestos. The gas flame should be admitted into this furnace tangentially so as to cause a vortex of flame. Gas may be introduced through a piece of inch gas tube. The air may be brought in through a piece of half-inch brass tube held centrally in the iron gas pipe by means of three studs, and passing out at the other end of it through a collar furnished with leather. Its nozzle should be about half an inch behind the end of the iron gas tube, which should just project into the exterior of the furnace, and thus be well removed from the heat. It is held in position by a casting of metal furnished with six screws, and bolted on to a strap of iron put round the furnace-body.

This plan is similar to that of Fletcher's new cyclone furnaces, but they are made with too thin walls, which causes loss of heat.

A blower called Roots' blower is frequently employed, but I find that it causes a great loss of power. The foot blowers of indiarubber supplied by Fletcher constantly get out of order. I prefer the French leather foot blowers enclosed in an iron cylinder. One of these, No. 2 size, can be easily driven by a one-sixth horse power dynamo. The dynamo makes about 1,200 revolutions per minute when working, but is geared down so as to make about twenty strokes of the pedal per minute, and this gives a very powerful

blast, more than enough for the furnace. A good free supply of gas is needed through a three-quarter inch pipe. Such a furnace uses 20 cubic feet of gas per hour. It becomes red-hot in about six minutes, and will easily melt cast-iron. It may be used, of course, for all sorts of metallurgical operations. Instead of gas for fuel, petroleum may be employed. In this case it should be allowed to drip on to a gauze put in front of the blower, so as to be blown into the furnace in the form of fine spray. If the furnace becomes damaged, all that is necessary is to patch it up with some fireclay mixed with water to a paste, to which a little water-glass is added. This prevents it from splitting. If water-glass cannot be got, some borax may be used to mix with the fireclay. A crucible supported on a suitable stand, or block of fireclay, should be warmed gently, and then the ingredients of the flux introduced into it. This would be—

Silica	3 parts.
Red lead	from 2 to 3 parts.
Calcined carbonate of soda . . .	1 part.

For a hard enamel, only 2 parts of red lead would be put in; for a soft enamel, 3 parts. About $2\frac{3}{4}$ parts of minium makes a good soft enamel.

A crucible $4\frac{1}{2}$ inches high and $3\frac{1}{2}$ inches diameter across the mouth holds about 900 grammes, or nearly 2 lb., of melted dense flint.

The materials must be finely powdered and well mixed, and should be introduced into the furnace through a small wide funnel by means of a spoon. Both spoon and funnel should be provided with long handles. After the first ebullition is over and the

mass sinks down, more and more material should be added till the crucible is full. A steady heat should be kept up for about fifteen hours. The glass will become limpid and clean in about two hours, but the long heating is necessary to make it thoroughly uniform. Glass made from raw materials which is only exposed to two or three hours' heat will crack when used as enamel. When the enamel is ready, it will draw out easily into long threads. It should be poured out upon a slab of iron about a quarter of an inch thick which has a trace of grease on it. If poured over thin iron plate, it will make it red hot and stick.

I should never recommend the enameller to make his own flux. Excellent dense soda flint glass of a specific gravity about 3·5, and containing about 45 per cent. of oxide of lead, can be bought from the makers of optical glass, and nothing better can be desired. Messrs. Mantois, of Paris, make such a glass, as also do Messrs. Chance, the famous English makers. But, for reasons already given, soda glass should generally be used, not potash glass. It costs from 3*d.* to 6*d.* a pound. This is dearer than the usual price for the commoner kinds of flint. By using such glass as this as a foundation, enamel can easily be made with two or three hours' heating, but it is improved by longer exposure to a moderate heat.

As I have said, raw materials take a long heating before they incorporate. This is especially true of silica and alkalis. If silica has been well united to the alkali, lead can be soon melted into the compound, and will dissolve and make a durable glass.

When flint glass comes from the makers, it is in

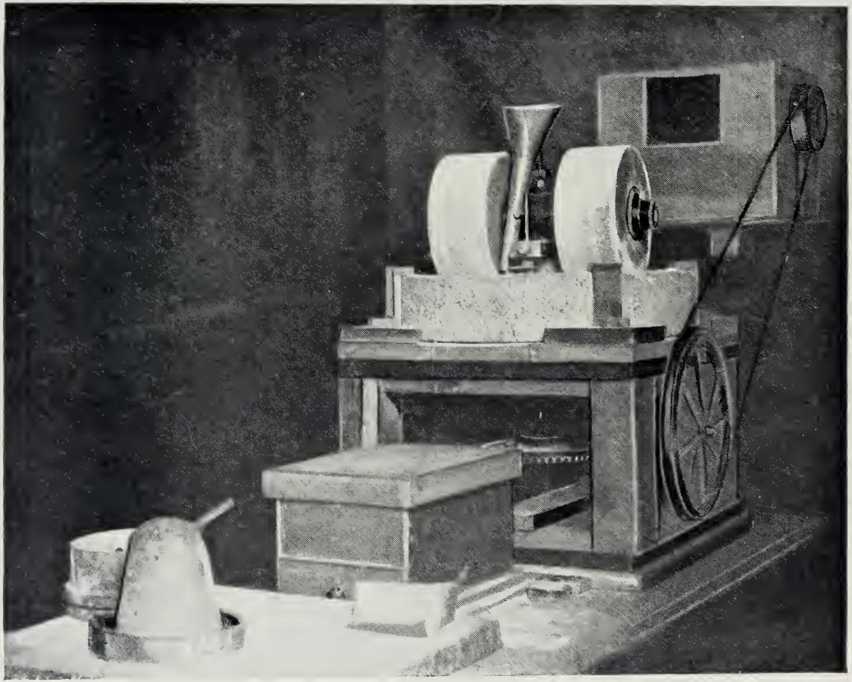
lumps about the size of a nut. It may be bought ready ground, but is often full of chips of iron.

It is not difficult to grind it for oneself.

For this purpose nothing is better than a small edge runner mill. The stones may be small, but the weight hung upon them should be at least $1\frac{1}{2}$ cwt. on each runner. They may be driven by a quarter horse-power dynamo. They should be made of the hardest Scottish granite, and run at a rate of about fifteen revolutions per minute on a bedstone of the same material. A glass bell-jar with a hole in the top will serve as a cover, and permit the introduction of the glass, which should be broken up on a slab of granite to the size of peas. It falls down a funnel, whence a pipe conveys it right under the runners. It is not desirable to grind the glass too fine, for in that case the lead is apt to become reduced. It is amply sufficient if it passes through a sieve eighty meshes to the inch.

In this way powdered flux can be obtained, which can be used both for coating plates and also for making coloured enamels. There is, however, a danger in melting up glass so heavily charged as this with lead that the lead should become reduced, especially if the glass has been very finely ground. To obviate this danger, 2 per cent. of nitrate of potash in powder may be well mixed up with it. The colouring matters may now be added.

These consist of metallic oxides. It is not in most cases necessary, nor in some desirable, that the metals should be added in the state of oxide. On the contrary, almost any salts of the metals will do, such as carbonates or nitrates, for the acids they contain



Grinding Mill of Scottish Granite, driven by a dynamo. The weight put on the runners is obtained by hanging it underneath the vertical shaft which drives them.

will generally be expelled at a red heat and replaced by silicic acid.

It is not desirable to use sulphates, for on fusion the sulphur is given off, and this is apt to combine with the lead and form sulphide of lead, a heavy black substance. The sulphur also is apt to give a yellow tone to the enamel.

In many cases salts of the metals dissolve more easily than the oxides. Thus, permanganate of potash is better than oxide of manganese, and nitrate of copper is better than copper oxide. The salts may be dissolved in water, and the powdered flux wetted with it, well stirred up to diffuse the salt, and then dried. The nitrate of potash may then be weighed out and added, the mixture well stirred together, and then melted.

Some colours may be made by a much simpler process if the metallic oxides on which they depend are very soluble. Thus, turquoise copper can be made by melting up a crucible full of lumps of dense flint, and then stirring into it about 4 per cent. of dry powdered crystals of nitrate of copper. Bichromate of potash can also be used in this way. So also can permanganate of potash, but it requires a good stirring to dissolve it. The advantage of this plan, where practicable, is that the composition of the dense flint is as little as possible interfered with, and the resulting enamel is therefore more tough and homogeneous.

The materials used for colouring glass are as follows :—

Black sesquioxide of cobalt (Co_2O_3).—This, when united with silica and potash, forms the blue glass

known as smalt blue. The oxide when pure is a very powerful colouring agent. Even one part in a thousand of glass gives a fine royal blue. The ore of cobalt is called "saffre," from which the word sapphire is derived. It contains a large quantity of arsenic, which makes the operation of roasting it dangerous. In consequence the German miners called it after the "kobolds," or spirits of the mines. Saffre contains about half its bulk of black oxide. The colour of cobalt is brightened by the addition of some alumina (*i.e.*, oxide of aluminium or clay). It is darkened by the addition of iron manganese or uranium. Phosphate of cobalt can also be employed. One and a half parts of phosphate are equivalent to one of oxide of cobalt.

Black oxide of copper (cupric oxide, Cu_2O) is the scale formed on copper when heated to redness in the air. It colours glass a light sea green. With soda glass its colour is more blue than with potash glass, and varies with the degree of heat at which it is melted. Greater heat produces a more green tinge. About 2 per cent. of it gives a fine sea green. It may simply be added in powder to a crucible full of melted glass. It is a treacherous colour, as it tends to make the enamel brittle. Another plan is to employ nitrate of copper by dissolving say 10 grammes of copper in nitric acid, then add 20 grammes of dry anhydrous carbonate of soda, or a corresponding proportion of ordinary carbonate. The mixture will strongly effervesce; when the effervescence has ceased, enough nitric acid should be added to convert all the soda into nitrate of soda. Make it up to 200 c.c. in bulk, and wet it with from 700 to 1,000 grammes of

powdered dense flint glass; dry it and melt. It gives a fine, somewhat greenish turquoise. The nitrate of soda serves to prevent the lead from being reduced.

Red oxide or suboxide of copper (Cu_2O) is used to give a red colour, either transparent or opaque, to glass, but is not employed by the enamel-maker, because gold serves the same purpose much better. (See farther on, under the heading "Gold.") When black oxide of copper is added in larger quantity, as say 6 per cent., and then, when melted, some iron filings are added and slowly cooled, we obtain the sparkling mass known as "aventurine." The colour of copper enamel can be modulated by the addition of oxide of zinc, oxide of cobalt, oxide of chromium, or oxide of uranium.

The oxide of iron most usually employed is the red peroxide or ferric oxide (Fe_2O_3) known as rouge or crocus martis. It dissolves with some difficulty in silica. When 5 per cent. of this is *dissolved* in glass it gives a sickly green colour like bile. If simply mixed into the melted glass in large quantity, say 20 per cent., so that it is not dissolved, it affords a red opaque enamel like red sealing-wax, which is useful for many purposes. Rouge is generally made by calcining sulphate of iron. The red oxide of iron used in medicine is obtained by precipitating a salt of iron with ammonia. It is much more soluble in silica than rouge. So that for making opaque red, rouge is preferable; but for dissolving and making green, the precipitated red oxide of the druggists is the best.

A fine green may be made of a union of precipitated

iron peroxide and chromate of potash, but the shorter way is to procure chromate of iron, of which there are two sorts, the dark and the light, which both serve equally well.

About 3 per cent. of chromate of iron gives to enamel a fine bottle-green colour, the shades of which can be modulated by the addition of copper, cobalt, and uranium.

Black binoxide of manganese (MnO_2) gives a reddish purple. About 4 per cent. is a useful proportion. When in the crucible, oxygen is disengaged, which causes the ingredients to foam up; hence the crucible should only be filled one-third full at first, and the rest added gradually. Manganese is called in German brown-stone; and by the French, peridot, after a town near Limoges, where it was found. It is not easy to get good oxide quite free from iron.

When manganese is melted up without any oxidizing agent being present, or when it is long heated, especially when it contains a little iron, it takes a reddish tone. The violet hue is obtained only when the manganese is kept well oxidized with nitrate of potash.

Mixed with rouge, manganese forms a fine warm reddish brown, and is the only sort of transparent red which the old masters possessed, at least till gold-red was discovered, the date and introduction of which seem a mystery.

Manganese gives with cobalt a bluish violet, and with cobalt, iron, and copper it gives a deep black.

Instead of using this oxide of manganese we may employ one and a half times the amount of permanganate of potash, which may be dissolved in water,

and the powdered flux wetted with it, and then dried. This gives a very fine colour, and I think it is preferable to using the oxide, for it is much more pure.

Some sorts of binoxide of manganese are black, some brown, but their quality is the same. It is a difficult pigment to get pure, and for fine colour purity is desirable.

Yellow (so-called) *sesquioxide of uranium*, or what is really uranate of soda, is a most useful colour. Its only drawback is that its colouring power is feeble. It takes 15 per cent. to make a full yellow. It mixes well with copper and chromium to form brilliant greens, and with gold it forms a splendid orange colour, but its use requires some precautions.

If simply mixed with powdered dense flint, with the usual 2 per cent. of potash, it gives a bottle-green, which, after many hours of heating, becomes at last a dirty yellow.

In order to get the canary colour out of uranium, it seems necessary to keep it reduced, and therefore the best way of making it is to heat together some ordinary flint glass, such as Chance's potash flint, 10 per cent. of minium, from 10 to 15 per cent. of uranium, and 2 per cent. of potash. This in about an hour gives a fine yellow.

It is important to get good uranium. The brand known as "Joachims-thal" is the best. It is of a fine deep yellow, almost an orange, and can be got from the vendors of chemicals for china manufacturers.

Chromium.—If employed in the form of the green sesquioxide (Cr_2O_2), it gives a fine opaque green.

This is due to the fact that the sesquioxide dissolves in glass only with great difficulty. And most of it therefore remains suspended. If, however, yellow bichromate of potash is used ($KOCrO_3$), it is all dissolved and gives a bilious green. When a large quantity, such as 8 per cent., is used, the glass becomes surcharged, and the chromium crystallizes out, producing green aventurine.

But chromium is best used for greens in combination with iron, as above described.

Nickel is a valuable colouring agent. Carbonate of nickel ($NiCO_3$), a green powder, imparts to the glass a fine cold sepia brown; from 2 to 3 per cent. may be employed.

Gold.—Great mystery has been made as to the production of crimson from gold, and all sorts of accounts are given in the books of its manufacture. In some the tedious process of making purple of Cassius is recommended, which I will not detail here as it is of no use to the enameller. I do not, however, know any book in which a sufficiently detailed method is described to enable the workman to succeed with certainty. The one I give will therefore be the more valuable because I have tried it so many times as to be certain of its success. To make the gold-red it is essential that some raw minium should be present. Hence then it will not do to begin with dense flint. We must begin with a light flint. The ordinary powdered light potash flint sold by Chance & Co. serves admirably for the purpose.

Soak a kilogramme of it in 300 cubic centimetres of water, in which 1 gramme of chloride of gold has been dissolved; mix well. The ordinary chloride

used for photography does very well. Add 250 grammes of minium, and 100 grammes of yellow uranate of soda, or, as it is usually termed in trade, "orange oxide of uranium." Add also 20 grammes of nitrate of potash in powder. Put these all in a basin and mix them well, and evaporate till they are dry. Then triturate them all together in a large mortar till they are perfectly mixed.

Heat a crucible in the furnace till it is of a bright red, and then fill it with the powder. Put on the lid and get up a sharp heat for half an hour. The mixture first turns a light opaque pinkish brown, then in about 15 minutes it fuses into a clear canary yellow, which deepens during the next 15 minutes. It may be stirred once, but stirring is apt to cause the lead to be reduced, and if the preliminary mixing has been well done it is not necessary. Then take out a specimen on the tip of a rod, let it cool and reheat it. If on heating it appears orange, the operation is near completion, but the heat must be continued till in about 35 to 40 minutes on reheating the glass becomes of a blood red. The contents of the crucible may now be poured, and will be of a bright full canary yellow. The pieces may be used in this way, and will turn red on firing, or else bits may be held in the tongs in the muffle furnace till the colour comes, or put on bits of platinum and reheated.

But the critical moment must not be lost, for if the operation be continued too long, the glass becomes of a light brown semi-opaque tint, and it is then almost impossible to get it back again. The tint will be fire-red.

Instead of the uranium, 2 per cent. of black pro-

toxide of tin or stannous oxide (Sno) may be added. In this case the colour, instead of being a fire-red, will be of a more purple tone. A much longer period of heating is however required.

These two colours are most valuable for enamelling.

It may be a matter of some surprise that so short a heating produces the result. It seems however true that, though alkalis take a long time to unite with silica, lead is soon and easily dissolved in glass.

I have done many enamels with gold made as above described. They are very brilliant, and have never split. On the contrary, they seem remarkably elastic and stable.

The reader must also be cautioned against statements in several manuals such as that gold-red cannot be made with glass containing lead, or again that it cannot be made except with glass containing lead, or again that it cannot be made except with borax. All these statements are false. In fact, it is possible to make gold-red almost anyhow, if only the exact proportion of the ingredients is hit off. And these exact proportions seem in each case to be a matter of experiment.

About ·05 per cent. of black oxide of cobalt added to the gold and tin will give the red a violet hue, but so like that of manganese as not to present any particular advantage over enamel made with manganese.

On white these reds made with gold give a fair effect, but their chief use is upon gold paillons, when they give a glorious colour. Iron can also be employed as what I may call a precipitant, but its effect is not so uniform. In fact, nothing equals uranium.

It acts best when about 15 per cent. is put in, and the resulting glass is beautifully smooth and workable.

Copper may also be made to give a deep red colour with the use of tin. But at least 5 per cent. of red oxide of copper is required, otherwise the glass becomes transparent green. The colour comes, like that of gold, upon reheating. The large amount of copper required makes the enamel too deep for use. It is asserted that some German firms have succeeded in making thinly-tinted red glass with copper oxide. As a rule, however, it is only used for "flashing" glass, that is to say, in a very thin layer on the surface of transparent glass.

In the middle ages, copper was much used in this manner.

During the French Revolution a large number of the finest church windows in France were destroyed in the belief that the red glass was rich in gold, but the chemists having shown that it was made with copper, the work of destruction was stayed.

If a very large proportion of red oxide is put in, and the heat not made too great, the red oxide is melted into and suspended in the glass, and a rich crimson opaque enamel is obtained.

Tungsten can also be employed to strike down the red colour in copper and gold, but it seems to possess no particular advantages.

I may add that the above-suggested theory of metallic precipitation, akin to the sort of action that goes on in the development of platinotype prints, is a mere hypothesis, for at present the chemistry of the coloration of glass with gold and copper is not understood.

Iridium oxide is an intensely black powder. It colours glass most powerfully; ·03 per cent. of it gives a good grey. But its greatest use is, when mechanically mixed with 2 to 4 parts of flux, as an opaque black pigment. It serves then the same purposes as Indian ink does on paper.

Selenium is a black brittle substance, somewhat akin to sulphur. If pounded up and mixed intimately with pounded glass and about 2 per cent. of nitrate of potash, it gives a fine yellow colour. But when a reducing agent is present it gives a rose colour.

Opaque white is made by melting white oxide of tin (stannic acid) with powdered glass. The tin is not dissolved in the glass, but suspended in it like a pigment. But the tin has so strong a reducing power that, if a mixture of powdered dense flint glass and oxide of tin were melted together, the lead would become reduced and the mixture blackened. The tin must therefore be introduced by an artifice. This can be done by taking light flint and mixing it with sufficient minium to change it into dense flint, and at the same time introducing the tin, for the minium keeps the mixture oxidized; a little nitrate of potash might also be added for the same purpose. Thus if we take of powdered light flint, 6 parts; minium, 1 part; white stannic acid, 2 parts; we shall get a white very well adapted for grisaille. It will be so hard as to be almost impossible to pour, and must be dragged out of the crucible. But it is a splendid material for use for grisaille. It is, however, almost too hard and devoid of polish, and if employed for doing grisaille, must be glazed over with flux when finished. To soften it is an easy matter by introducing some

borax. This will bring it down to any refined degree of fusibility, till it is soft enough to be useful for enamelling watch faces, or any other similar purpose. The lead and tin may also, at least in part, be introduced into the enamel in the form of "putty powder."

Without the use of some borax it is almost impossible to get a fusible and yet brilliant white.

Nothing but a very hard white is of use for doing grisaille. Messrs. Emery, the colour makers, make an excellent white, known as No. 100, for use by china painters, which I can recommend strongly for grisaille, as it stands the fire well in the half-tones.

The following recapitulation of the method of making some of the most useful ordinary enamels may be useful. In each case soda flint glass is used as a foundation, ordinary light flint, such as is employed for table glass, being used if a hard enamel is wanted, and dense optical flint of about 3·5 specific gravity being used if a softer and more brilliant enamel is desired.

In most cases the addition of a little nitrate of potash is desirable, to keep the lead from being reduced; 2 per cent. is on the average sufficient. The longer the heating the better the result; three or four hours (except for gold) is the least that should be given. On a large scale, with big crucibles, the time required will be much longer.

Grass green.—Melt powdered flint glass with 3 per cent. of chromate of iron, and 2 per cent. of nitrate of potash. Or, mix powdered flint glass with 1·6 per cent. of black oxide of copper, ·8 per cent. of bichromate of potash, and 2 per cent. of nitrate of potash.

Dark rifle green.—The usual quantity of nitrate of potash, and from 10 to 20 per cent. of nitrate of copper.

Turquoise.—This must be made with soda glass, for potash glass produces a bluish green like a faded turquoise. Into a crucible of melted glass stir $1\frac{1}{4}$ per cent. of black oxide of copper; it will dissolve easily. Or 2 per cent. of nitrate of copper in powdered crystals may be used.

A pale sky blue.—Powdered flint with 2 per cent. of nitrate of potash, and ·2 per cent. of fluor-spar.

Iron blue.—To the materials for turquoise, add ·025 up to ·05 per cent. of black oxide of cobalt.

A deep royal blue.—Powdered flint glass with the usual quantity of nitrate of potash, and 2 per cent. of black oxide of cobalt.

A medium royal blue.—The same, but with ·6 per cent. of oxide of cobalt.

A light royal blue.—The same, but with ·12 per cent. of oxide of cobalt.

All the above may be toned to a more sober hue by the admixture of a little iron. The modern blues are rather brighter than the ancient, because the cobalt now obtainable is purer. Instead of iron, if about 5 per cent. of yellow oxide of uranium is introduced, the same effect will be produced.

Black.—Cobalt, 3 per cent.; manganese, 2 per cent.; brown chromate of iron, 2 per cent.

Antique red.—Manganese, 2 per cent.; rouge, 2 per cent.; nit. potash, 2 per cent.

Purple.—Permanganate of potash, 4 per cent. to 8 per cent.; nit. potash, 2 per cent.; or, binoxide of manganese, from 3 per cent. to 6 per cent.

The permanganate may be simply stirred into a crucible of molten glass, in which case no nitrate of potash need be employed, but it needs a good stirring to disseminate the colour throughout the glass.

Brown.—1 per cent. of green carbonate of nickel; 2 per cent. of nitrate of potash.

Dove-coloured grey.—1·3 per cent. of black oxide of manganese; ·03 per cent. of bichloride of platinum in crystals.

Slate grey.—Bichloride of platinum, ·05 per cent. nitrate of potash, 2 per cent.

Fire ruby (see page 126).

Ruby (blood colour).—Made as before described: ·1 per cent. of chloride of gold, 2 per cent. of protoxide of tin, and 2 per cent. of potash.

Claret colour.—As for ruby, but with the addition of ·05 per cent. of cobalt. And note here that when such small quantities of colouring matter are to be added it is best done by adding the requisite amount of powdered glass coloured with cobalt, or whatever else it may be wished to add.

Canary yellow.—15 per cent. of uranate of soda; 2 per cent. of nitrate of potash.

A fine orange yellow.—4 per cent. of metallic selenium; 2 per cent. of nitrate of potash.

The selenium must be very finely powdered, and then with the potash well incorporated up with the pounded glass, for selenium, like sulphur, is very volatile.

After making each batch of enamel it should be tried. This is best done by preparing a copper label bulged like a plaque, and with a hole in it, and of dimensions say 1 inch by 2 inches. This should be

covered with any common white and fired, and then with a pretty thick coating of the colour and fired. While it is just so hot that it can be touched, it should be put under a tap of cold water, and if it does not crack it may be pronounced sound. Its composition should then be indicated on a gummed label posted on the back, and the whole used as a label to the jar containing the enamel. It thus serves as a colour index, a record of composition, and a test of the resistance and durability of the enamel. A bad enamel will generally crack in the course of a month after it is made, but I never knew one to go in this way that had stood the water test.

Upon the whole, I hardly recommend the amateur to be at the pains to make his own enamels. They can be got of excellent quality, but of the harder sort, from Soyer, Rue Chapon, in Paris. The prices vary from four francs a kilogramme upwards. Messrs. Millencent, 5, Rue de Chautepoulet, Geneva, make some very fine opalescent enamels, but charge the absurd price of about twenty francs a kilo. for all of them, even for common cobalt blue.

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